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NATIONAL DAM INSPECTION PROGRAM. CLOE DAM (NDI ID NUMBER PA-421--ETC(U)
JUN 79 DACW31-79-C-0014
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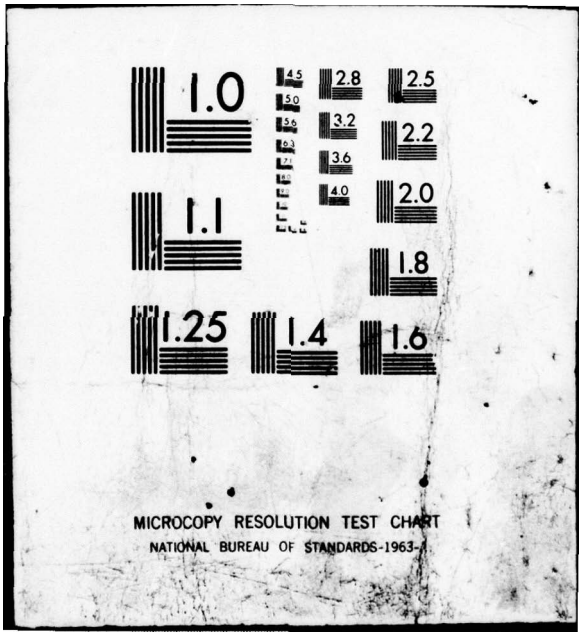
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OHIO RIVER BASIN
JACKSON RUN, JEFFERSON COUNTY

PENNSYLVANIA

CLOE DAM

NDI I.D. NO: PA-421
DER I.D. NO: 33-2

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

Contract #DACW31-79-C-0014

PREPARED FOR

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND 21203

BY

D'APPOLONIA CONSULTING ENGINEERS
10 DUFF ROAD
PITTSBURGH, PA. 15235

JUNE 1979

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Department of the Army, Office of Chief of Engineers, Washington, D.C. 20314.

The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon visual observations and review of available data. Detailed investigation and analyses involving topographic mapping, subsurface investigations, material testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the inspection is intended to identify any need for such studies which should be performed by the owner.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of the dam depends on numerous and constantly changing internal and external factors which are evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The spillway design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

The assessment of the conditions and recommendations was made by the consulting engineer in accordance with generally and currently accepted engineering principles and practices.

(11) Jun 79 (6) National Dam Inspection Program. Cloe Dam (NDI ID Number PA-421, DER ID Number 33-2), Ohio River Basin, Jackson Run, Jefferson County, Pennsylvania. Phase I Inspection Report.

PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM

(15) DACW 31-79-C-0014

NAME OF DAM: Cloe Dam
STATE LOCATED: Pennsylvania
COUNTY LOCATED: Jefferson
STREAM: Jackson Run, a tributary of Mahoning Creek
DATE OF INSPECTION: April 5 and May 4, 1979

(12) 69 p.

ASSESSMENT: Based on the evaluation of the existing conditions, the condition of Cloe Dam is considered to be good.

Several seeps and a swampy area were found below the toe of the dam. However, these conditions are not considered to be significant relative to the overall integrity of the structure.

The concrete in the emergency and primary spillway overflow structures was found to be deteriorated. Structural cracks and seepage beneath the overflow structures were observed. It appears that the spillway structures would incur significant structural damage in the event of large flows through the spillways. However, damage to the spillway structures is not considered to be a threat to the structural stability of the embankment.

Fish Commission personnel reported that the outlet works sluice gate for the reservoir has not been operated in the recent past. It is therefore recommended that the operational condition of the outlet works sluice gate should be evaluated.

The spillway cannot pass the recommended spillway design flood of full PMF without overtopping the embankment; therefore, it is classified to be inadequate according to the recommended criteria. However, the spillway is not considered to be seriously inadequate because it is estimated that overtopping of the embankment by less than 0.1 foot during the passage of 50 percent PMF would not constitute a significant breach potential.

It is recommended that the following be implemented immediately or on a continuing basis:

1. The owner should immediately initiate additional studies to more accurately ascertain the spillway capacity and the nature and extent of improvements required to provide adequate spillway capacity. Filling of the low area on the crest of the dam should be considered.

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2. The operational condition of the outlet works sluice gate should be evaluated and necessary maintenance performed.

3. Necessary remedial work should be performed on the spillway concrete structures to avoid further deterioration of concrete and structural damage.

4. Missing riprap on the upstream slope should be replaced.

5. The dam and appurtenant structures should be inspected regularly with the emphasis on seepage areas and necessary maintenance performed.

Lawrence D. Andersen, P.E.
Vice President

June 25, 1979
Date

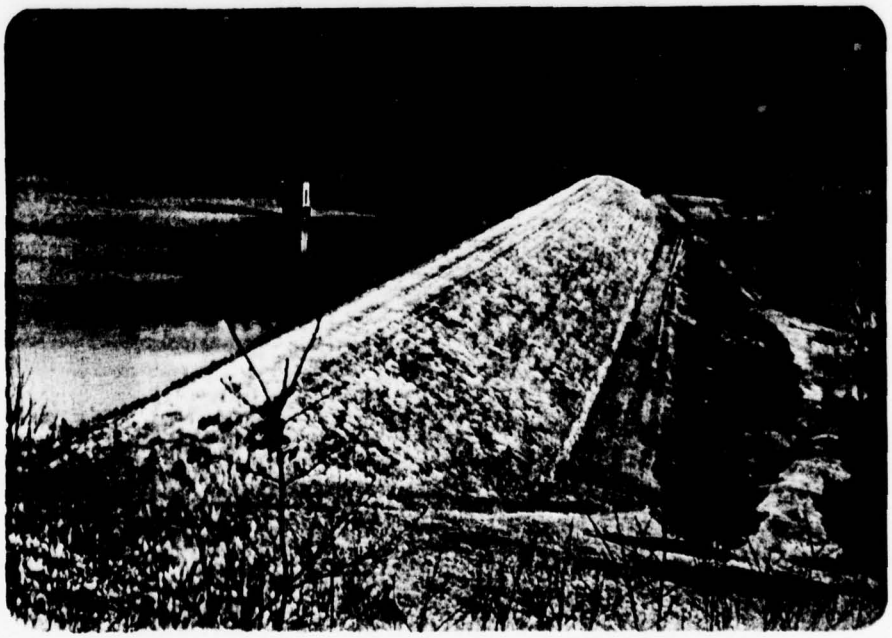
Approved by:

JAMES W. PECK
Colonel, Corps of Engineers
District Engineer

27 July 1979
Date

CLOE DAM
NDI I.D. NO. PA-421
APRIL 5, 1979

Upstream Face



Downstream Face

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PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM
CLOE DAM
NDI I.D. NO. PA-421
DER I.D. NO. 33-2

SECTION 1
PROJECT INFORMATION

1.1 General

a. Authority. The inspection was performed pursuant to the authority granted by The National Dam Inspection Act, Public Law 92-367, to the Secretary of the Army, through the Corps of Engineers, to conduct inspections of dams throughout the United States.

b. Purpose. The purpose of this inspection is to determine if the dam constitutes a hazard to human life or property.

1.2 Description of Project

a. Dam and Appurtenances. Cloe Dam consists of an earth embankment approximately 900 feet long with a maximum height of 43 feet from the downstream toe and a crest width of 14 feet. The upstream face of the dam is protected by hand-placed riprap. The crest and the downstream slope extending from crest level to a berm at midheight of the embankment is covered with grass. The downstream slope below the berm level is protected by riprap. The flood discharge facilities for the dam consist of an 85-foot-wide rectangular concrete overflow structure located on the left abutment (looking downstream). A concrete wall parallel to the flow direction divides the overflow structure into two open channels. The 50-foot-wide channel adjacent to the left abutment constitutes the primary spillway of the reservoir. The remaining 35-foot section of the overflow structure adjacent to the embankment provides auxiliary spillway capacity. The crest of the auxiliary spillway section is 0.4 foot above the crest level of the primary spillway, as measured during this inspection. The outlet works consist of a reinforced concrete intake tower, two 10-inch cast-iron supply pipes, and two 24-inch cast-iron outlet pipes. Pipes through the embankment are encased in concrete. Flow through the outlet pipes is controlled by manually operated sluice gates located in the intake tower. The two 24-inch outlet pipes constitute the emergency drawdown facility for the reservoir.

b. Location. The dam is located on Jackson Run, a tributary of Mahoning Creek, approximately 3 miles east of Punxsatawney in Bell Township, Jefferson County, Pennsylvania (Plate 1). Downstream from

the dam, Jackson Run flows approximately one mile west, where it joins Mahoning Creek. The towns of Cloe and Punxsatawney are located along Mahoning Creek approximately one and three miles below the mouth of Jackson Run, respectively. There are two houses in the Jackson Run valley downstream from the dam. Jackson Run flows under the Baltimore and Ohio Railroad before joining Mahoning Creek. It is estimated that failure of the dam would cause loss of life and property damage at the houses in Jackson Run valley and further downstream in the towns of Cloe and Punxsatawney.

c. Size Classification. Intermediate (based on 43-foot height and 590 acre-feet storage capacity).

d. Hazard Classification. High (based on downstream conditions).

e. Ownership. Pennsylvania Fish Commission (address: Mr. Edward R. Miller, Director of Fisheries and Engineering, R. D. 3, Box 70, Bellefonte, Pennsylvania 16823).

f. Purpose of Dam. Recreation.

g. Design and Construction History. The dam was designed and constructed by the Buffalo, Rochester and Pittsburgh Railroad Company with completion in 1909. In 1923, the dam was enlarged by the subsequent owner of the dam, Cloe Water Company. The enlargement consisted of increasing the height of the embankment by five feet and the construction of a new spillway.

h. Normal Operating Procedure. The reservoir is normally maintained at the crest level of the uncontrolled primary spillway. When the lake is at or above the primary spillway level, inflow is discharged through the uncontrolled primary and auxiliary spillways. The outlet works sluice gates are normally closed.

In the design drawings, the normal pool level is shown to be at Elevation 1360. However, on the U.S. Geological Survey (USGS) Punxsatawney 7.5-minute quadrangle map, photorevised 1973, the pool elevation is shown to be between Elevation 1380 and 1400. Therefore, it appears that the elevations shown on the design drawings are relative to a datum different than the current USGS datum.

1.3 Pertinent Data. Elevations referred to in this and subsequent sections of the report are calculated based on approximate field measurements, assuming the primary spillway crest level to be at Elevation 1380 (USGS Datum).

a. Drainage Area - Three square miles

b. Discharge at Dam Site (cfs)

Maximum known flood at dam site	Unknown
Outlet conduit at maximum pool	100
Gated spillway capacity at maximum pool	N/A
Ungated spillway capacity at maximum pool	2550
Total spillway capacity at maximum pool	2550

c. Elevation (USGS Datum) (feet)

Top of dam	1384.8 (measured low spot); 1385.5 (as designed)
Maximum pool	1384.8
Normal pool	1380
Upstream invert outlet works	1345±
Downstream invert outlet works	1343±
Streambed at center line	1343±
Maximum tailwater	Unknown

d. Reservoir Length (feet)

Normal pool level	2000
Maximum pool level	2200 (estimated)

e. Storage (acre-feet)

Normal pool level	350
Maximum pool level	590

f. Reservoir Surface (acres)

Normal pool level	26
Maximum pool level	36±

g. Dam

Type	Earth
Length	800 feet
Height	43 feet
Top width	12 feet
Side slopes	Downstream: 2H:1V Upstream: 1.9H:1V (from crest level to a level 20 feet below crest); 3H:1V (the remaining portion of the upstream slope)

Zoning	Yes
Impervious core	Yes
Cutoff	Yes
Grout curtain	No

h. Regulating Outlet

Type	Two 24-inch cast-iron pipes
Length	220± feet
Closure	Sluice gates at control tower
Access	Control tower
Regulating facilities	Sluice gates

i. Spillway

	Primary	Emergency
Type	Rectangular channel	Rectangular channel
Length	50 feet	35 feet
Crest elevation	1380 feet	1380.4 feet
Upstream channel	Lake	Lake
Downstream channel	Rectangular concrete channel	Rectangular concrete channel

SECTION 2
DESIGN DATA

2.1 Design

a. Data Available. The available information was provided by the Commonwealth of Pennsylvania, Department of Environmental Resources (PennDER), and by the Pennsylvania Fish Commission.

(1) Hydrology and Hydraulics. Available information reports the design capacity of the spillways.

(2) Embankment. Available information consists of design drawings.

(3) Appurtenant Structures. Available information consists of design drawings.

b. Design Features

(1) Embankment

a. As designed, the dam (Plate 2) is a zoned embankment (Plate 3) with a reinforced concrete cutoff wall at the center of the dam extending from the foundation level to the dam crest for the entire length of the dam. In the design drawings, two zones are identified: (1) "selected clay" - a zone 12 feet wide at the base of the dam tapering to zero thickness at the crest level immediately upstream of the concrete cutoff wall; (2) "shale and clay fill" forming the upstream and downstream shell sections of the dam. The original embankment (completed in 1910) was designed to have a 2.5H to 1V slope on the downstream face and a 3H to 1V slope on the upstream face. The embankment as enlarged in 1923 has a 2H to 1V slope on the downstream face, 1.9H to 1V and 3H to 1V slopes on the upstream face. The 1.9H to 1V slope on the upstream face extends from the crest level to a level about 15 feet below the normal pool level.

b. The reinforced concrete cutoff wall was designed to be 8 feet thick from the foundation of the core wall to the base of the embankment. Through the embankment, the width of the concrete core wall was uniformly reduced from 8 feet at the

base level to one foot at the original crest level of the dam. During the 1923 enlargement, the core wall was extended to an elevation one foot below the new crest level.

(2) Appurtenant Structures. The appurtenant structures of the dam consist of uncontrolled primary and auxiliary spillways located on the left abutment and the outlet works. The spillway structures consist of an unlined approach channel and an 85-foot-wide concrete overflow structure which discharges onto a concrete apron which in turn discharges into an earth channel. The 85-foot-wide overflow structure constitutes the overflow section for both the primary and auxiliary spillways. A concrete wall in the overflow structure parallel to the flow direction separates the overflow structure into two sections. The 50-foot-wide section adjacent to the left abutment is the primary spillway of the reservoir. The crest level of the remaining 35-foot section of the overflow structure is 0.4 foot above the primary spillway crest level and constitutes the auxiliary spillway section. Both overflow sections discharge into a common concrete apron which in turn discharges into an earth channel.

The spillway overflow structure consists of a 12-inch reinforced concrete slab supported on continuous footings on approximately 10-foot centers oriented parallel to the flow direction. Plates 4 and 5 illustrate the details of this structure. The present overflow structure, which was built in 1923, is supported on the old overflow structure which had similar configurations.

The outlet works for the dam are located at the center of the embankment and consist of two 24-inch cast-iron outlet pipes and a concrete intake tower at the upstream end of the outlet pipes. The outlet pipes through the embankment are encased in concrete. Flow through the outlet pipes is controlled by sluice gates located at the upstream end operated from the intake tower. Plate 6 illustrates the details of the outlet works.

c. Design Data

(1) Hydrology and Hydraulics. In the design drawings dated 1923, the combined capacity of the primary and auxiliary spillways is reported to be 3452 cfs with no freeboard.

(2) Embankment. Other than design drawings, no engineering data are available on the design of the embankment.

(3) Appurtenant Structures. No design calculations are available for the appurtenant structures.

2.2 Construction. Very limited information is available on the construction of the dam. A state report entitled, Report Upon the

Application of the Cloe Water Company, dated June 21, 1913, summarizes the available information on the construction of the dam. This report indicates that the dam was constructed by BR&P Railroad Company under the supervision of Mr. Cleaver, division engineer of the company. It is reported that the foundation rock at the dam site consisted of shale throughout the entire length of the dam. The shale was encountered at depths 7 to 16 feet from the ground surface. An 18-inch-thick section of the concrete core wall was extended 2 to 3 feet into the foundation rock. It is indicated that the embankment material was placed in 12-inch-thick layers, wetted, and compacted by wagons and carts.

As completed in 1910, the dam was a 37-foot-high embankment with a single 35-foot-wide open channel spillway on the left abutment. In 1911, the spillway was enlarged by the construction of an additional 50-foot-wide overflow section on the left abutment. In 1923, the height of the embankment was increased by 6 feet to provide additional storage capacity. The 1923 enlargement work included extension of the concrete core wall, changing the downstream slope of the embankment from 2.5H to 1V to 2H to 1V with an addition of an 8-foot-wide bench at midheight of the embankment, and construction of a new spillway on top of the existing spillway on the left abutment.

2.3 Operation. Fish Commission personnel reported that there are no formal operating records for the dam.

2.4 Other Investigations. None reported.

2.5 Evaluation

a. Availability. The available information was provided by PennDER and the Pennsylvania Fish Commission.

b. Adequacy

(1) Hydrology and Hydraulics. The available information consists of the design discharge capacities of the spillways. This information is not considered to be adequate to assess the conformance of the spillway capacity to the current spillway design criteria.

(2) Embankment. The dam was apparently constructed according to the design drawings. In view of the age of the dam, completed in 1910, and later enlarged in 1923, all design approach and construction techniques are not likely to be in conformance with currently accepted engineering practices. Design documents lack such considerations as embankment slope stability and seepage analyses and other quantitative data to aid in the assessment of the adequacy of design. However, the design incorporated such components as embankment zoning, a cutoff wall extending to impervious foundation material, and slope protection. It is reported that the dam was constructed with adequate care.

(3) Appurtenant Structures. Review of the design drawings indicates that no significant design deficiences exist that would affect the overall performance of the appurtenant structures.

SECTION 3
VISUAL INSPECTION

3.1 Findings

a. General. The on-site inspection of Cloe Dam consisted of:

1. Visual inspection of the embankment, abutments, and embankment toe.

2. Visual examination of the spillways, intake tower, and the downstream end of the outlet conduit.

3. Observations of factors affecting the runoff potential of the drainage basin.

4. Evaluation of downstream area hazard potential.

The specific observations are illustrated on Plate 7 and by the photographs in Appendix C.

b. Embankment. The general inspection of the embankment consisted of searching for indications of structural distress, such as cracks, subsidence, bulging, wet areas, seeps and boils and observing general maintenance conditions, vegetative cover, erosion and other surficial features.

In general, the condition of the dam is considered to be good. Several seepage areas and one swampy area were found below the toe of the dam. One seepage area was located near the right abutment approximately 100 to 150 feet downstream from the toe of the dam. Flow from these seepage points was estimated to be in the range of 5 to 10 gallons per minute, respectively. Another seepage point, at the discharge channel of the outlet works, was flowing at approximately 1 to 2 gallons per minute. A swampy area was located approximately 150 feet downstream from the toe of the dam, to the left of the outlet works discharge channel. No flow appeared to be discharging from the swampy area. The downstream face of the dam was inspected and was found to be covered with well established grass in good condition. The riprap on the upstream face of the dam was also found to be in good condition, except for two locations. Near the left abutment and near the spillway approach channel, portions of the riprap apparently have been removed by vandals.

The top of the dam was surveyed, relative to the spillway crest elevation, and was found to have some vertical irregularities. While the design freeboard of the dam was 5.5 feet, the survey indicated freeboards ranging from 4.8 to 5.2 feet. The lowest area occurred approximately at the center of the embankment. The dam crest profile is illustrated on Plate 8.

c. Appurtenant Structures. The appurtenant structures were examined for deterioration or other signs of distress and obstructions that would limit flow. The spillway overflow structure was found to be in poor condition. The concrete was seriously spalled and cracked at various locations. Seepage was observed beneath the auxiliary side of the overflow structure. The condition of the structure suggests that major structural damage would be incurred in the event of large flows through the spillway. The visible portions of the outlet works structures were found to be in good condition. The downstream end of the outlet pipes was observed and no sign of distress was noted.

d. Reservoir Area. A map review indicates that the watershed is predominantly covered by woodlands. Several rural residential buildings are scattered throughout the watershed. A review of the regional geology (Appendix E) indicates that the shorelines of the reservoir are not likely to be susceptible to massive landslides which would affect the storage volume of the reservoir.

e. Downstream Channel. Downstream from the dam, Jackson Run flows west joining Mahoning Creek approximately one mile downstream from the dam. Two houses in this reach are considered to be within the potential flood plain of Jackson Run in the event of a dam failure. Further description of the downstream conditions is included in Section 1.2b.

3.2 Evaluation. While the condition of the embankment is considered to be good, the condition of the spillway overflow structure is assessed to be poor. It is considered that the spillway overflow structure would incur significant structural damage in the event of large flows through the spillway. However, this condition is not considered to be a threat to the overall integrity of the embankment. At this time, the seepage and swampy areas observed below the toe of the dam are not considered to have a significant effect on the overall stability of the embankment.

SECTION 4
OPERATIONAL FEATURES

4.1 Procedure. There are no formal operating procedures for the dam. The reservoir is normally maintained at the uncontrolled primary spillway crest level with excess inflow discharging over the spillways.

4.2 Maintenance of the Dam. The maintenance of the dam is considered to be good. The crest and the downstream face of the dam are covered with well established grass which is mowed periodically. The riprap on the upstream slope was found to be in good condition, except in two locations, where portions of the riprap appear to have been removed by vandals.

4.3 Maintenance of Operating Facilities. The maintenance condition of the operating facilities is considered to be good. However, Fish Commission personnel reported that the outlet conduit sluice gates have not been operated in the recent past. The operation of the sluice gates was not observed, because the operational condition of the gates was questionable.

4.4 Warning System. The formal warning system for Cloe Dam consists of an emergency preparedness plan prepared by the Pennsylvania Fish Commission. According to this procedure, the Pennsylvania Fish Commission Waterways patrolmen have been assigned the responsibility for the implementation of the emergency plan. The emergency operation plan consists of initiation of around-the-clock surveillance by the patrolmen when certain signs of distress listed in the plan are identified and notification of the Pennsylvania Fish Commission, local civil defense, and PennDER offices as to the existence of a dam emergency. The plan requires further action to be taken as jointly decided by the appropriate personnel following an on-site meeting.

4.5 Evaluation. Except for the deteriorated condition in the spillway structures, the maintenance condition of the remaining portions of the dam is considered to be good. It is recommended that the missing riprap on the upstream slope be replaced. The operational condition of the outlet pipe sluice gates was not observed. It is therefore recommended that the owner operate the sluice gates and perform necessary maintenance.

SECTION 5
HYDRAULICS AND HYDROLOGY

5.1 Evaluation of Features

a. Design Data. Cloe Dam has a watershed of three square miles and impounds a reservoir with a surface area of 26 acres at normal pool level. The flood discharge facilities for the dam consist of primary and auxiliary spillways located on the left abutment. The combined capacity of the spillways was determined to be 2550 cfs with freeboards of 4.8 and 4.2 for the primary and auxiliary spillways, respectively, relative to the low spot on the embankment crest. The combined design capacity of the spillways was reported to be 3452 cfs. The difference appears to be due to the difference in the design and surveyed freeboards available to the spillways and differing assumptions for the spillway discharge coefficient.

b. Experience Data. As previously stated, Cloe Dam is classified as an intermediate dam in the high hazard category. Under the recommended criteria for evaluating emergency spillway discharge capacity, such impoundments are required to pass full PMF.

The PMF inflow hydrograph for the reservoir was determined using the Dam Safety Version of the HEC-1 computer program developed by the Hydrologic Engineering Center of the U.S. Army, Corps of Engineers. Data used for the computer analysis are presented in Appendix D. The PMF inflow hydrograph was found to have a peak flow of 5623 cfs. Computer input and the summary of the computer output are also included in Appendix D.

c. Visual Observations. On the date of inspection, no conditions were observed that would indicate that the capacity of the spillways would be significantly reduced in the event of a flood. However, as previously noted, due to the poor structural condition, the spillway overflow structure may incur major damage in the event of large flows through the spillway.

d. Overtopping Potential. Various percentages of the PMF inflow hydrograph were routed through the reservoir. It was found that the spillway can pass 40 percent of the PMF without overtopping the low spot on the crest of the dam. For 50 percent PMF, the low spot on the crest would be overtopped for a duration of one hour with a maximum depth of 0.07 foot. For full PMF, the dam would be overtopped for a duration of 6.2 hours with a maximum depth of 1.1 feet. It is estimated that filling of the low areas on the crest to design elevation will increase the spillway capacity to approximately 60 percent PMF.

e. Spillway Adequacy. Since the spillway cannot pass the recommended spillway design flood of full PMF without overtopping the embankment, the spillway is classified to be inadequate according to the recommended criteria. However, the spillway is not considered to be seriously inadequate because it is estimated that overtopping of the embankment by less than 0.1 foot during the passage of 50 percent PMF would not constitute a significant breach potential. This conclusion was based on the observations that the concrete cutoff wall extending to the crest level would prevent rapid erosion of the crest, and well established grass on the downstream slope would provide protection against rapid erosion during overtopping.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

(1) Embankment. As discussed in Section 3, the field observations did not reveal any signs of distress that would significantly affect the stability of the dam at this time and none were reported in the past.

(2) Appurtenant Structures. While the visible portions of the outlet works structures were found to be in good condition, the condition of the spillway overflow structures was considered to be poor. The spillway concrete has seriously deteriorated and cracked. The condition of the structures suggests structural damage would be incurred in the event of large flows through the spillway. However, this condition is not considered to be a threat to the overall integrity of the embankment.

b. Design and Construction Data

(1) Embankment. The dam was designed in 1910, when a limited understanding of geotechnical behavior of earth structures existed. Consequently, available design and construction information does not provide any quantitative data to aid in the assessment of stability. However, as previously noted, the dam appears to have been constructed with adequate care and has performed satisfactorily since its construction. Therefore, the static stability of the dam is considered to be adequate.

(2) Appurtenant Structures. Other than design drawings, no design and construction data are known to exist for the appurtenant structures.

c. Operating Records. The structural stability of the dam is not considered to be affected by the operational features of the dam.

d. Post-Construction Changes. The latest reported post-construction change was made in 1923 when the dam was enlarged. Further description of this enlargement is included in Section 2.2.

e. Seismic Stability. The dam is located in Seismic Zone 1, and based on visual observations, the static stability of the dam is considered to be adequate. Therefore, based on the recommended criteria for the evaluation of seismic stability of dams, the structure is presumed to present no hazard from earthquakes.

SECTION 7
ASSESSMENT AND RECOMMENDATIONS/PROPOSED REMEDIAL MEASURES

7.1 Dam Assessment

a. Assessment. The visual observations indicate that except for the condition of the spillway overflow structure, the overall condition of Cloe Dam is good. Due to seriously deteriorating concrete in the spillway overflow structure, the condition of this appurtenance is assessed to be poor. However, this condition is not considered to be a threat to the overall integrity of the embankment. In general, no conditions were observed that would significantly affect the overall performance of the dam and none were reported in the past.

It is reported that the outlet pipe sluice gates have not been operated in the recent past. It is therefore recommended that the operational condition of the outlet pipe gates be evaluated and necessary maintenance performed.

The spillway capacity was evaluated according to the recommended procedure and was found to pass 40 percent PMF without overtopping the embankment. This capacity is less than the recommended spillway capacity of full PMF according to the size and hazard classification for the dam. Therefore, the spillway is classified to be inadequate. However, the spillway is not considered to be seriously inadequate because it is estimated that overtopping of the embankment by less than 0.1 foot during the passage of 50 percent PMF would not likely cause a failure of the dam.

b. Adequacy of Information. Available information in conjunction with the visual observations and the previous experience of the inspectors are considered to be sufficient to make a reasonable assessment of the condition of the dam.

c. Urgency. The following recommendations should be implemented immediately or on a continuing basis.

d. Necessity for Additional Data. In view of the inadequacy of the spillway capacity, the owner should initiate additional studies to more accurately ascertain the spillway capacity and the extent of improvements required to provide adequate spillway capacity.

7.2 Recommendations/Remedial Measures. It is recommended that:

1. The owner should immediately initiate additional studies to more accurately ascertain the spillway capacity and the nature and extent of improvements required to provide adequate spillway capacity. Filling of the low area on the crest of the dam should be considered.

2. The operational condition of the outlet works sluice gate should be evaluated and necessary maintenance performed.

3. Necessary remedial work should be performed on the spillway concrete structures to avoid further deterioration of concrete and structural damage.

4. Missing riprap on the upstream slope should be replaced.

5. The dam and appurtenant structures should be inspected regularly with the emphasis on seepage areas and necessary maintenance performed.

PLATES

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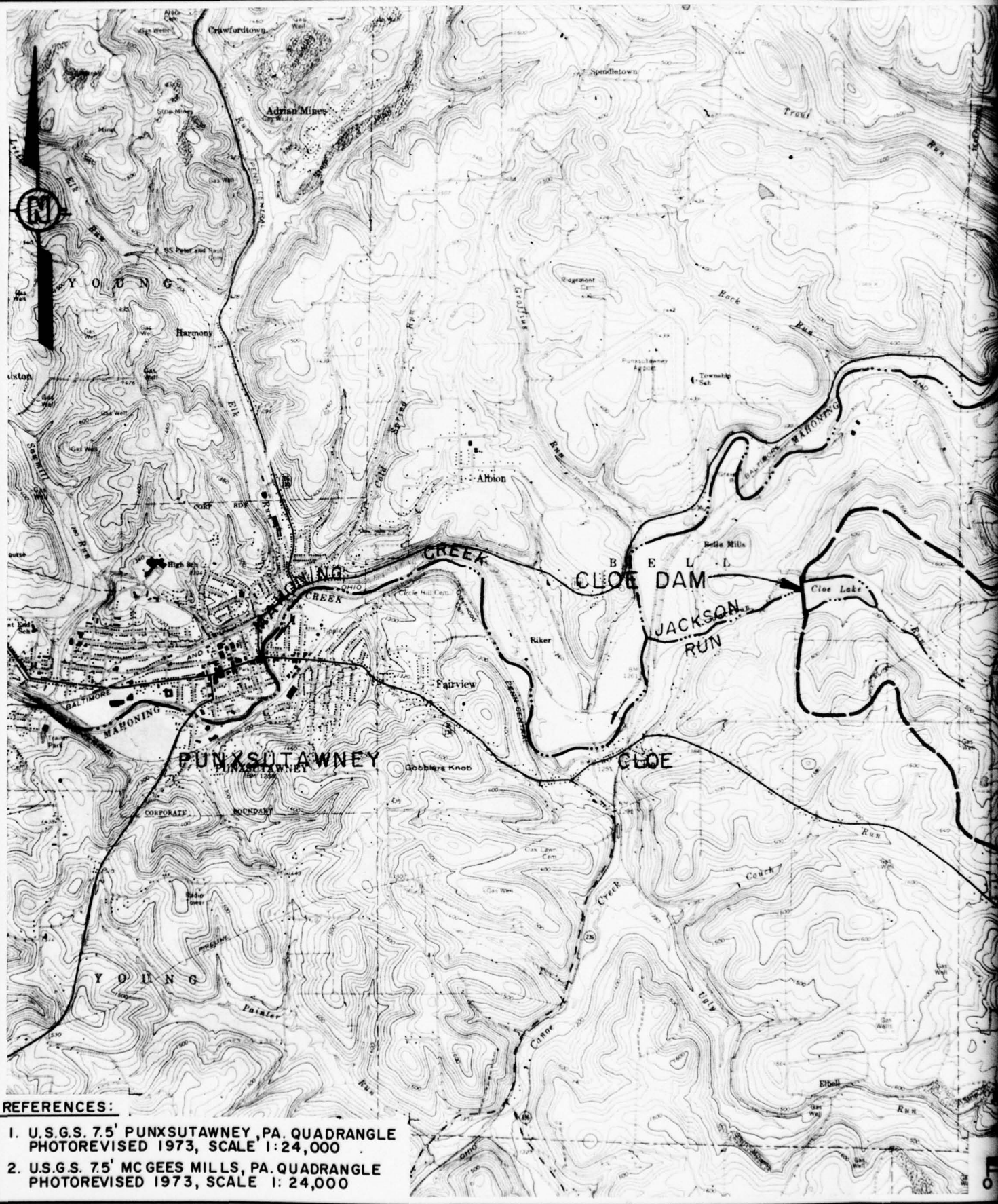


REFERENCES:

1. U.S.G.S. 7.5' PUNXSUTAWNEY, PA. QUADRANGLE PHOTOREVISED 1973, SCALE 1:24,000
2. U.S.G.S. 7.5' MC GEES MILLS, PA. QUADRANGLE PHOTOREVISED 1973, SCALE 1:24,000

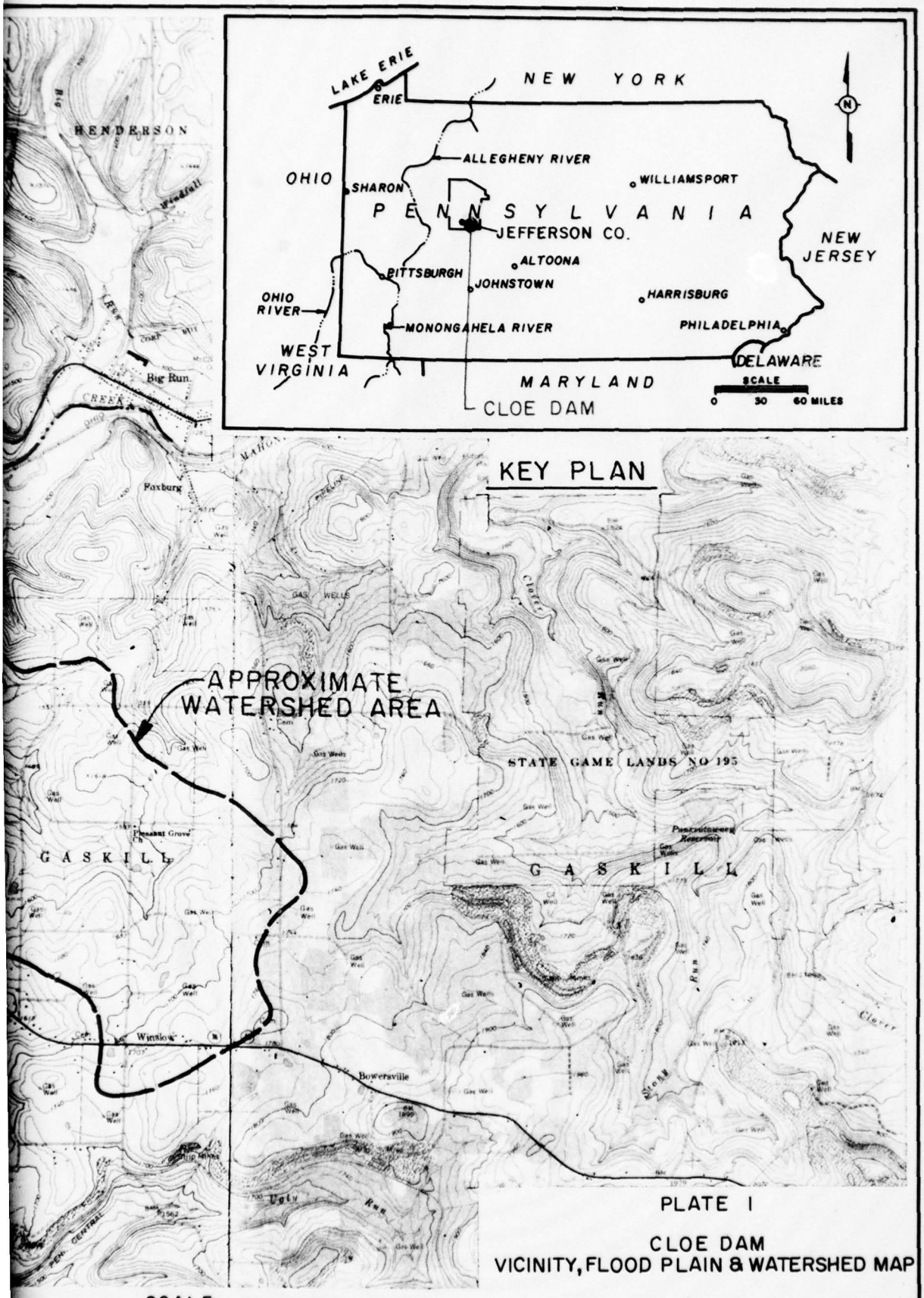
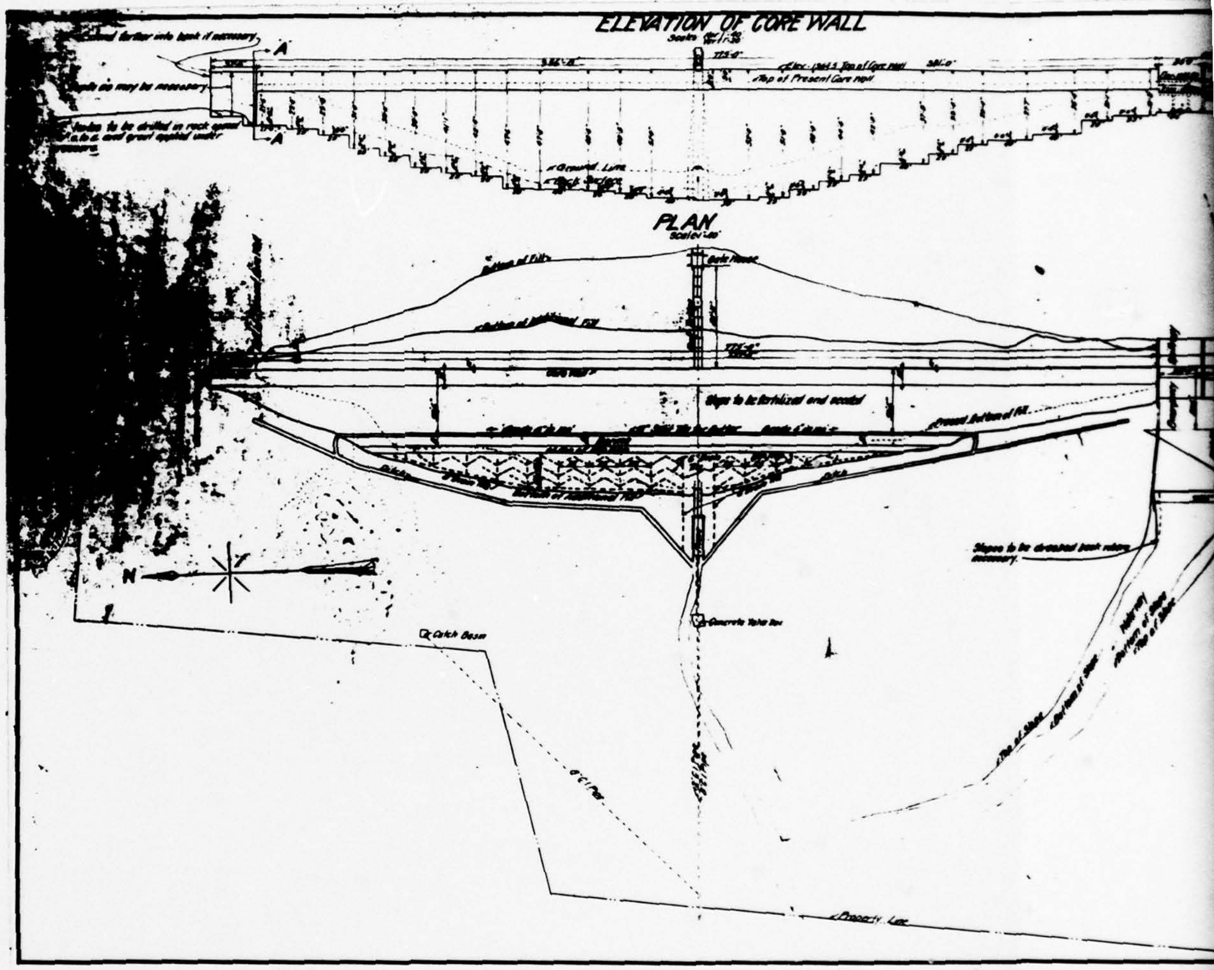


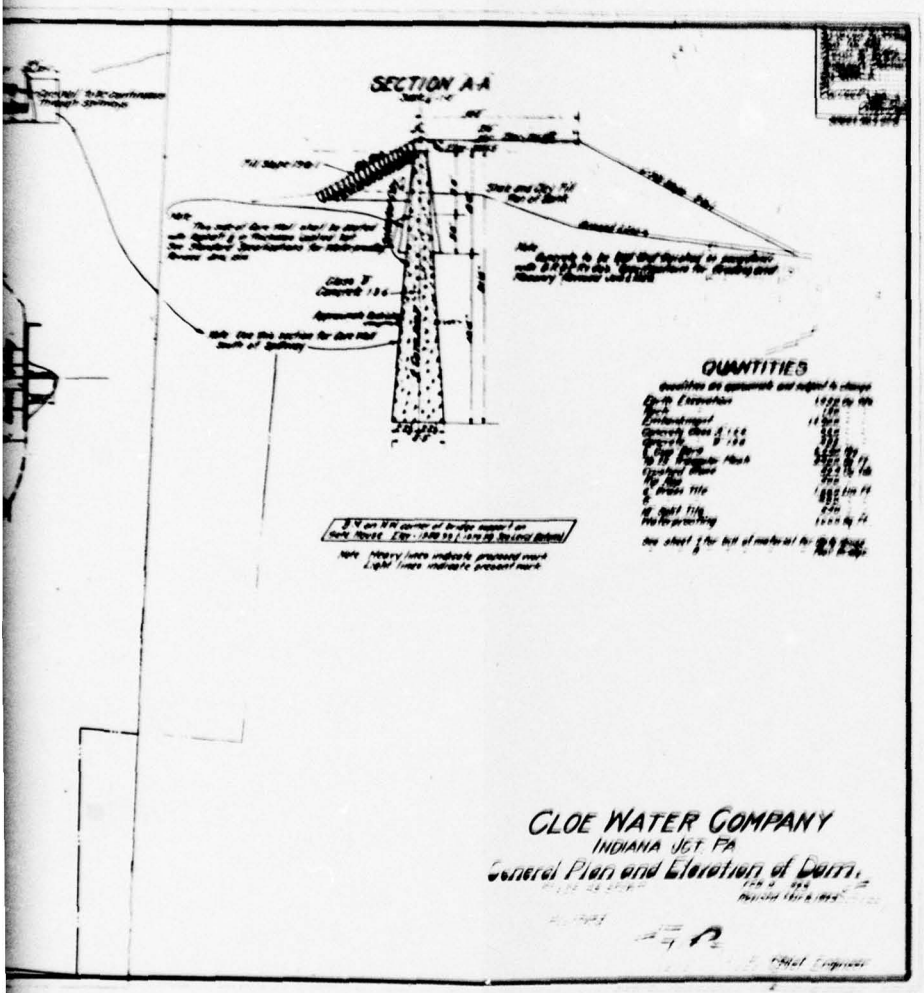
PLATE I

CLOE DAM
VICINITY, FLOOD PLAIN & WATERSHED MAP

D'APPOLONIA

DRAWN BY	ACS 5-22-79	CHECKED BY / APPROVED BY	BF 6-1-79 / [signature] 6-5-79
DRAWING NUMBER	78-367-B114		



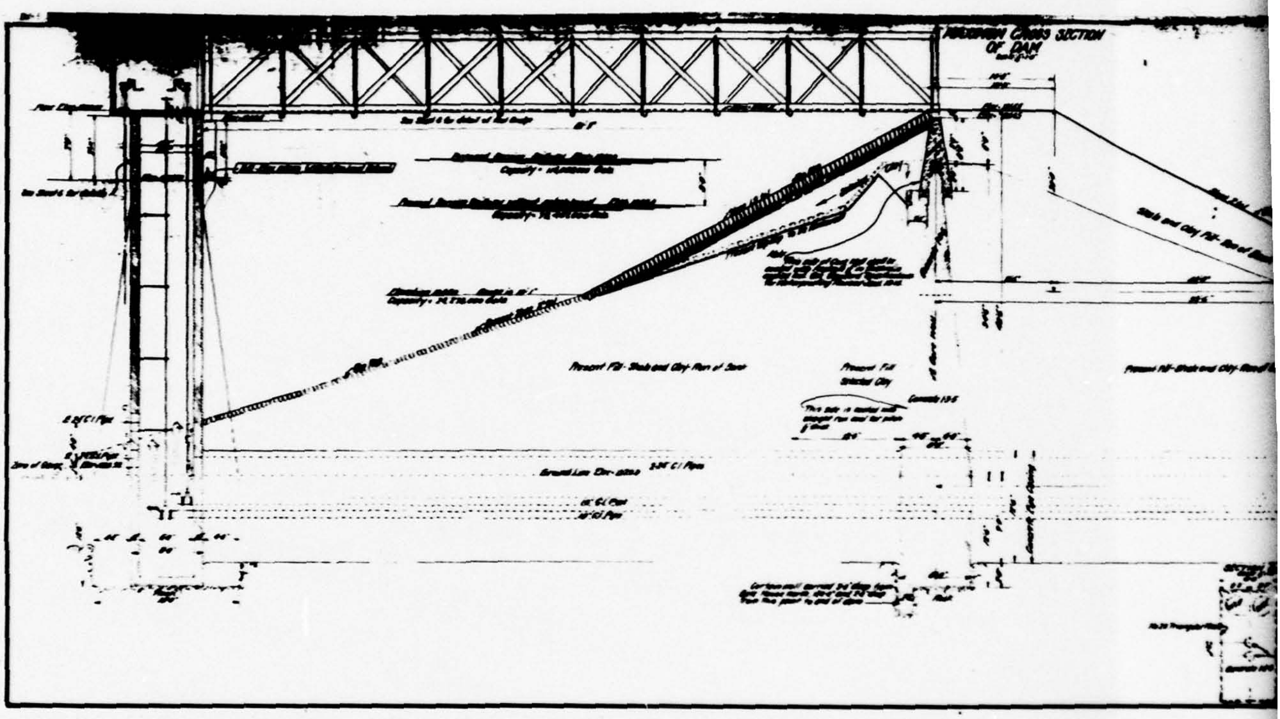


CLOE WATER COMPANY
INDIANA JCT. PA
General Plan and Elevation of Dam.

PLATE 2

D'APPOLONIA

DRAWN BY	ACS	CHECKED BY	RE	6-1-79	DRAWING NUMBER	78-567-B115
	5-22-79	APPROVED BY	[illegible]	6.5.79		



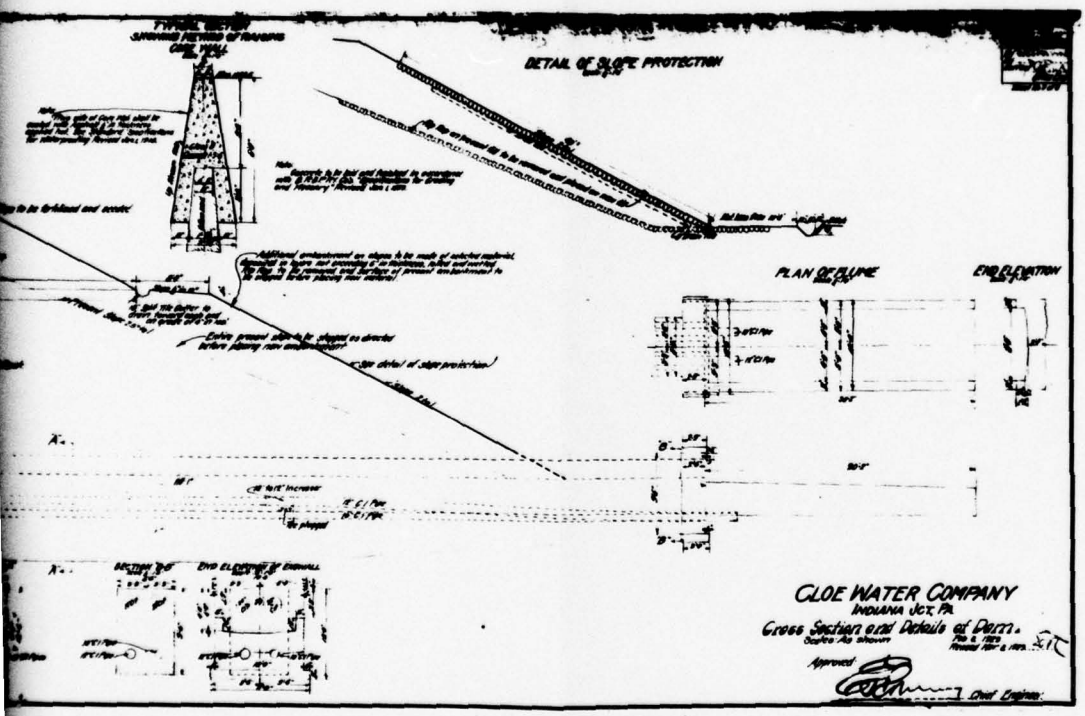
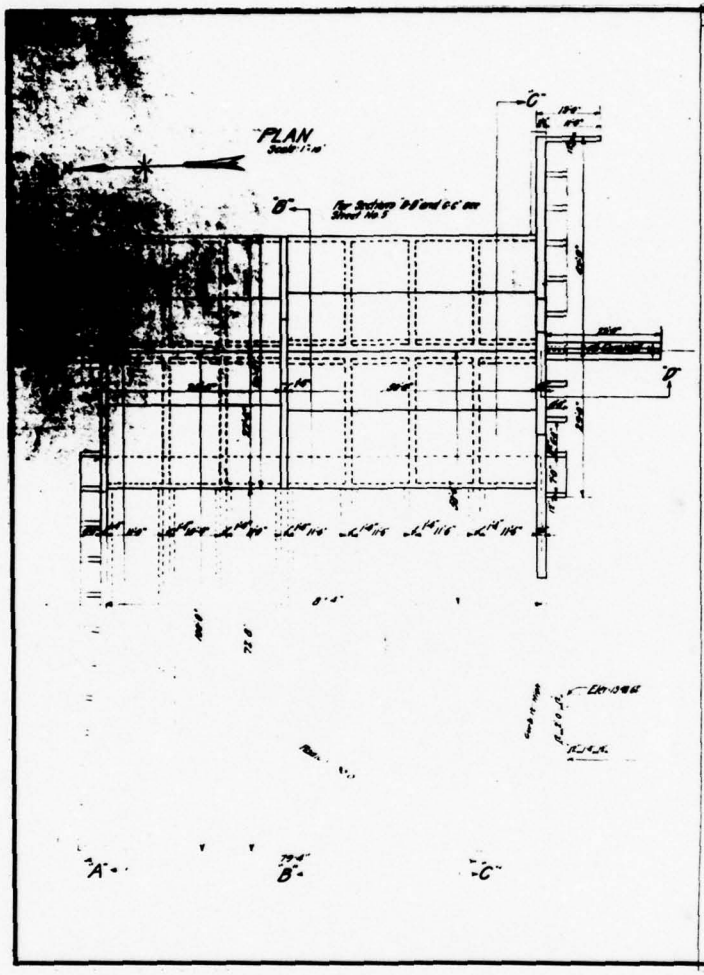
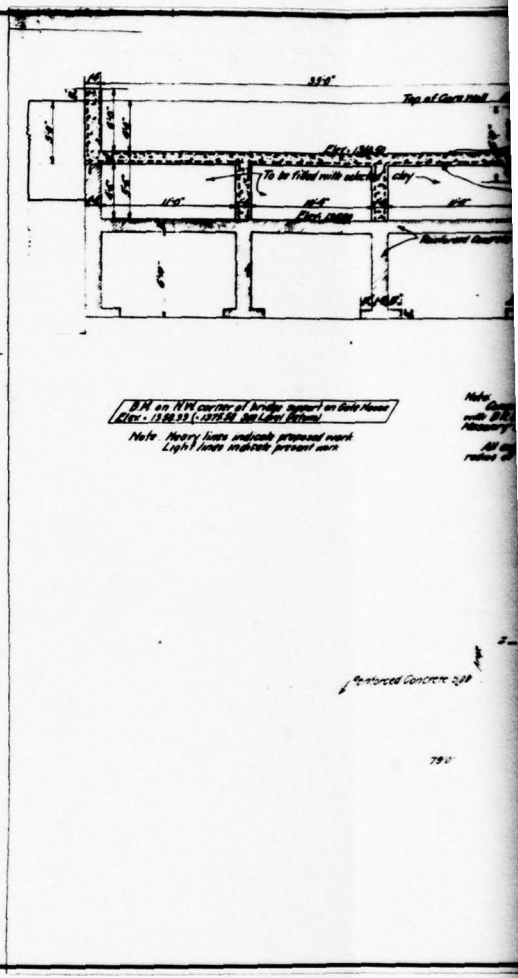


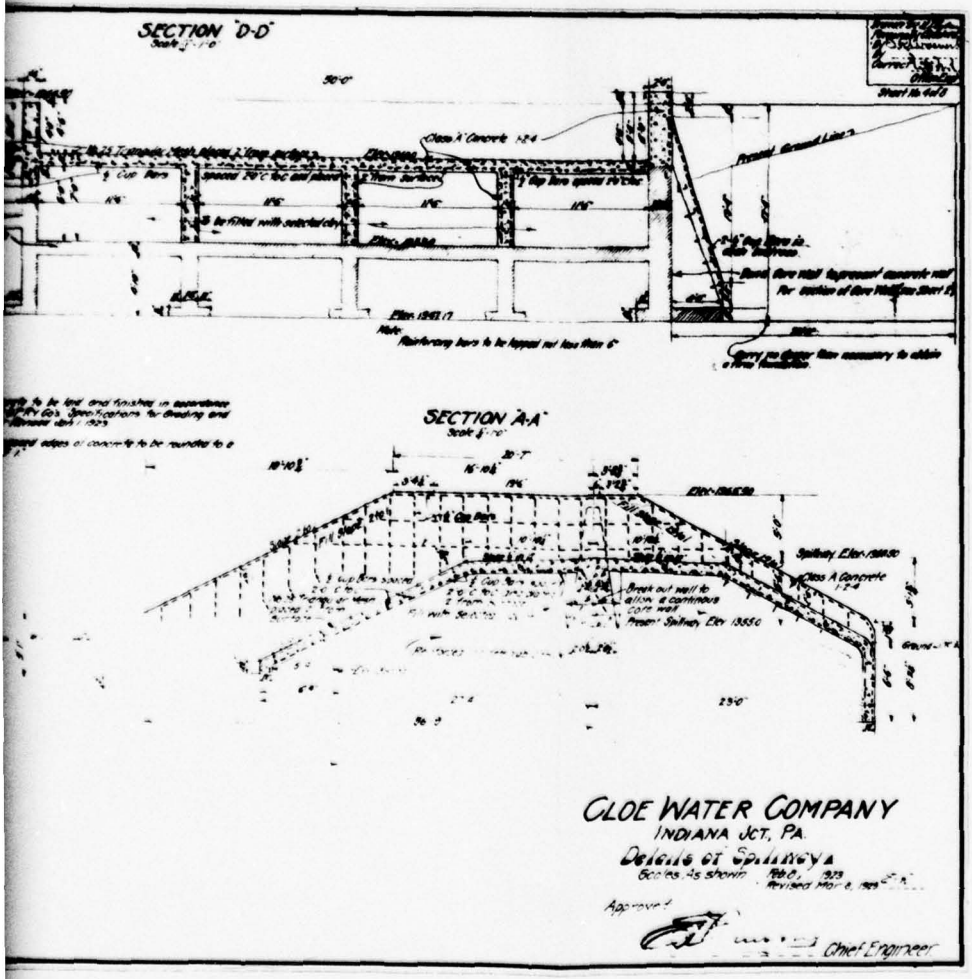
PLATE 3

D'APPOLONIA

DRAWN BY	ACS	CHECKED BY	BC	6-1-79	DRAWING NUMBER	78-367-B116
	5-22-79	APPROVED BY	[illegible]	6-5-79		





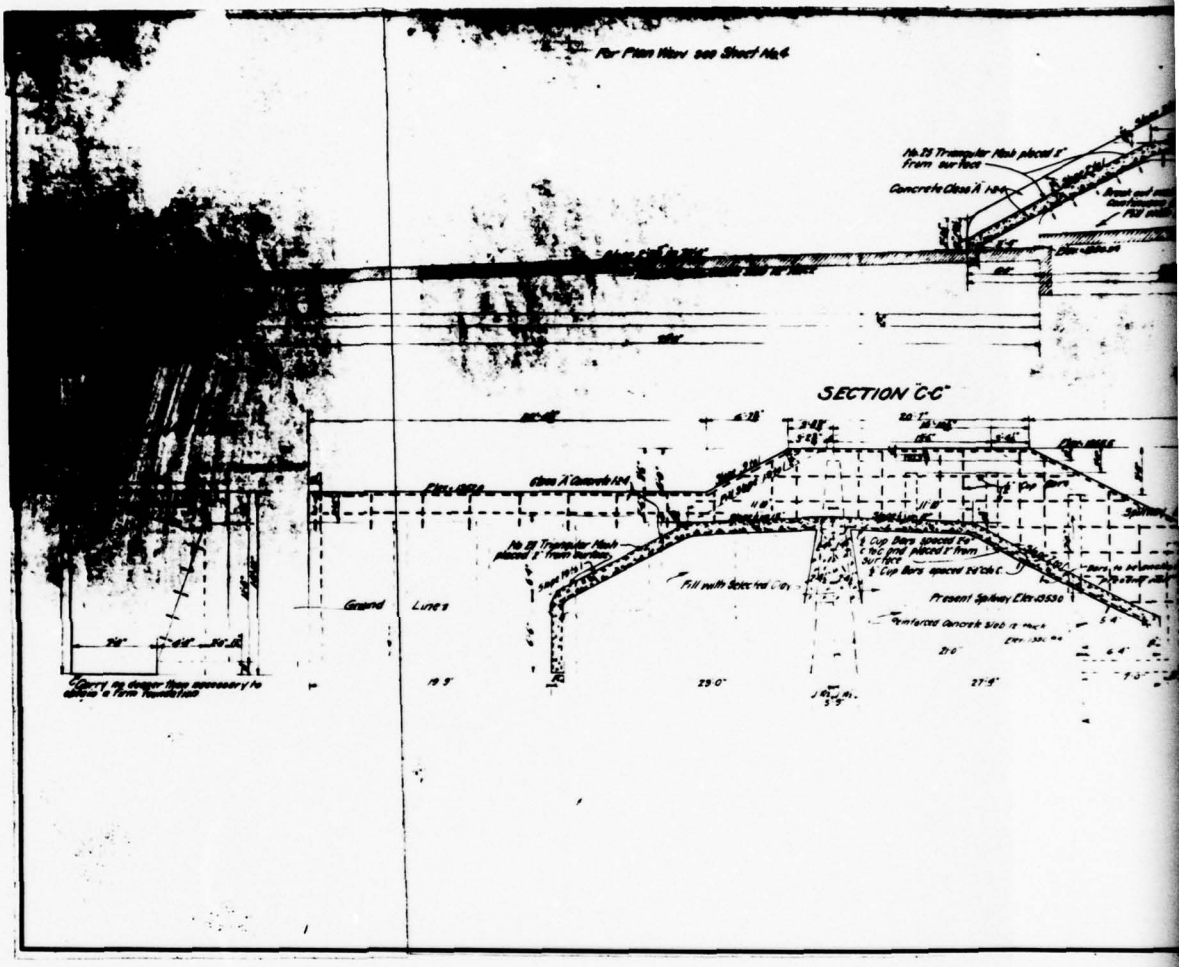


CLOE WATER COMPANY
INDIANA JCT, PA.
Details of Spillways
Scales as shown
Approved:
Chief Engineer

PLATE 4

D'APPOLONIA

DRAWN BY	ACS	CHECKED BY	BE	6-1-79	DRAWING NUMBER 78-367-B117
	5-22-79	APPROVED BY	[illegible]	6.5.79	



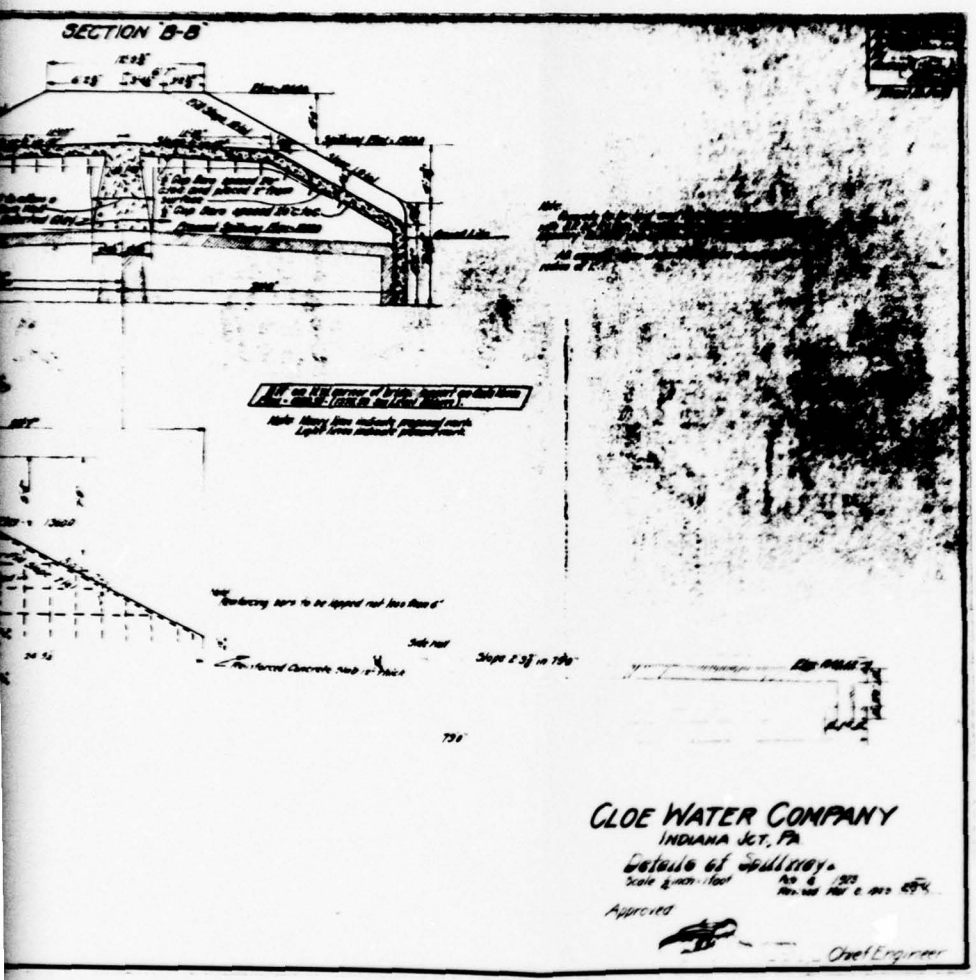
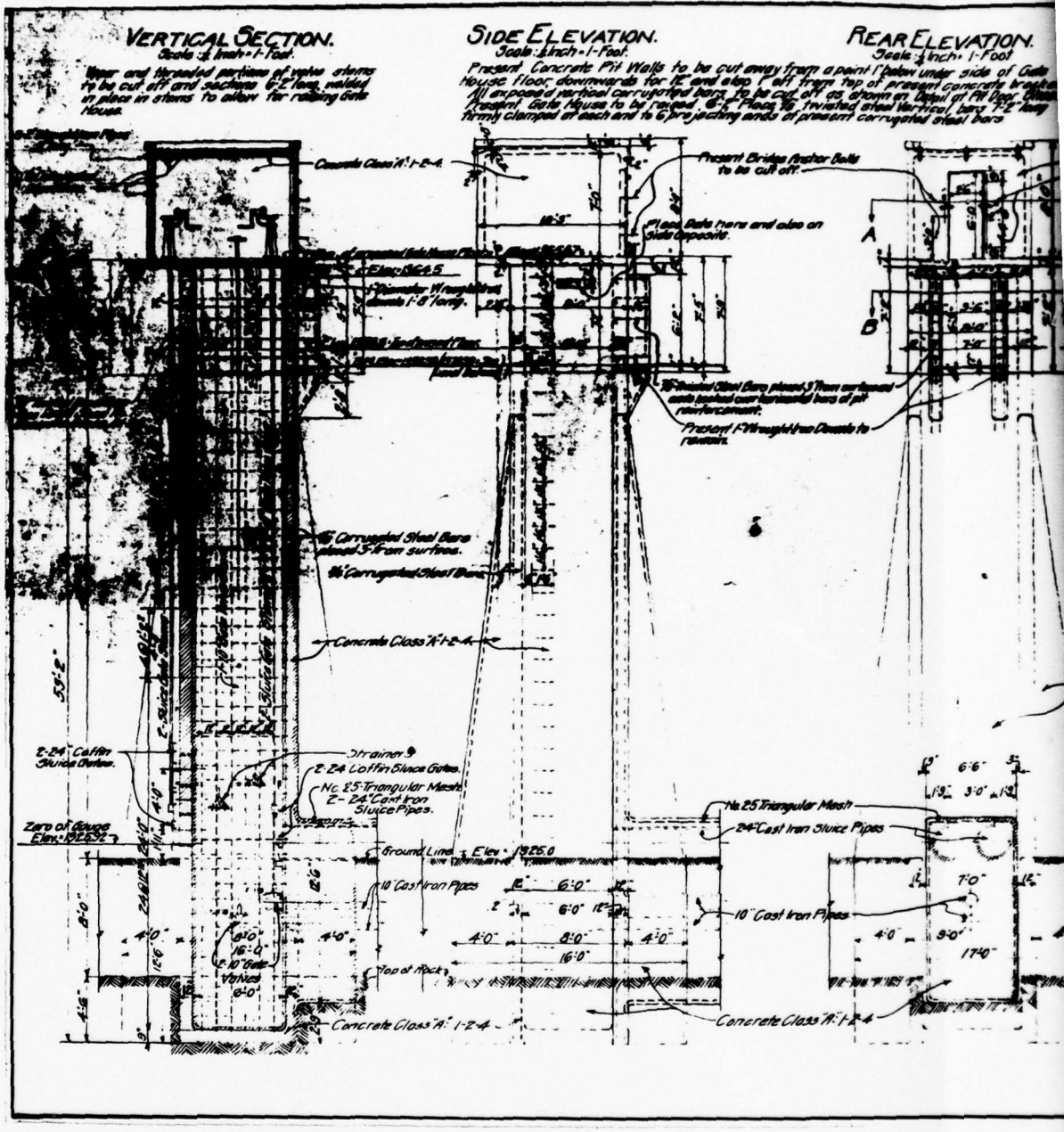


PLATE 5

D'APPOLONIA

DRAWN BY	ACS	CHECKED BY	RE	6-1-79	DRAWING
	5-22-79	APPROVED BY	[illegible]	6-5-79	NUMBER 78-367-B118



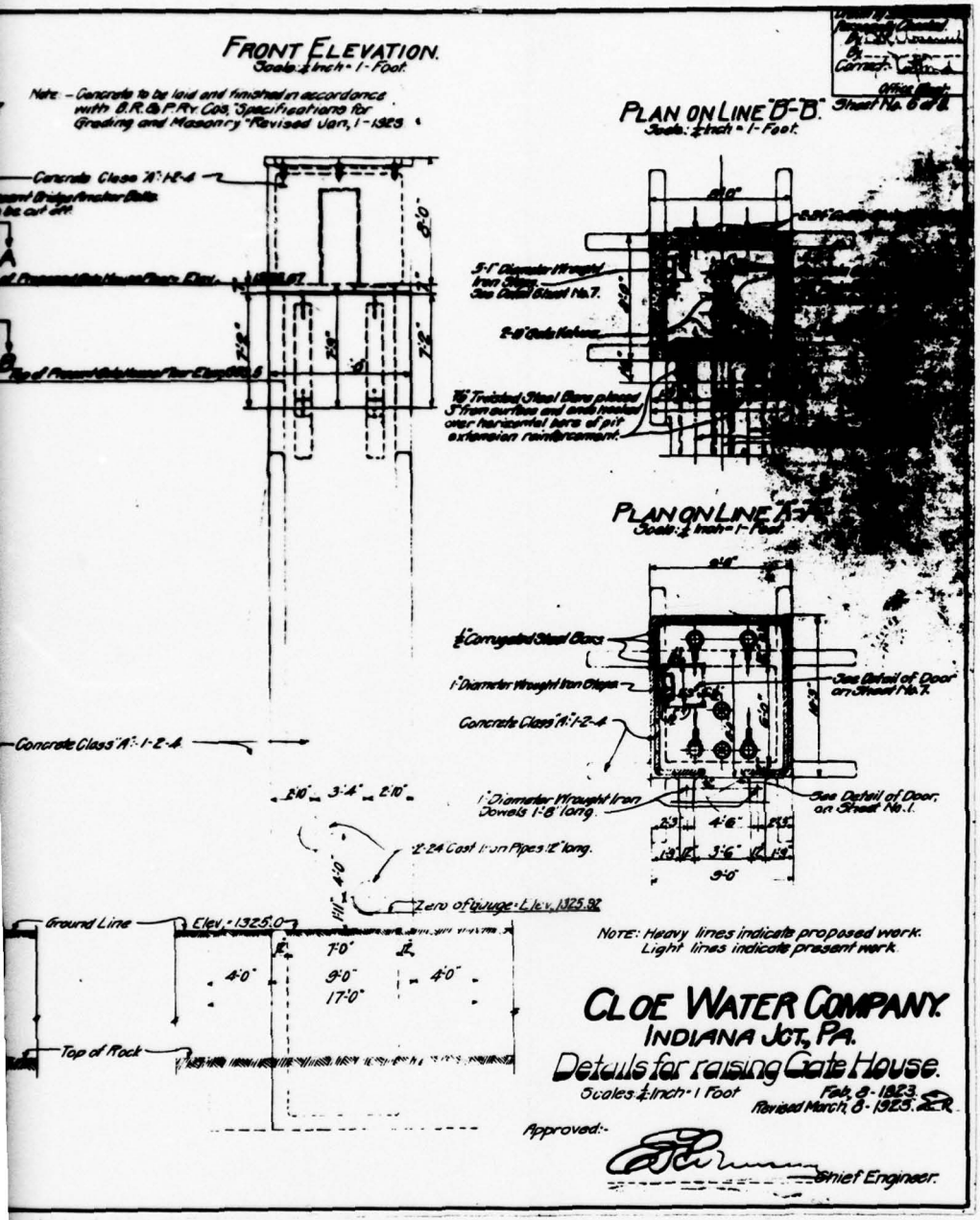
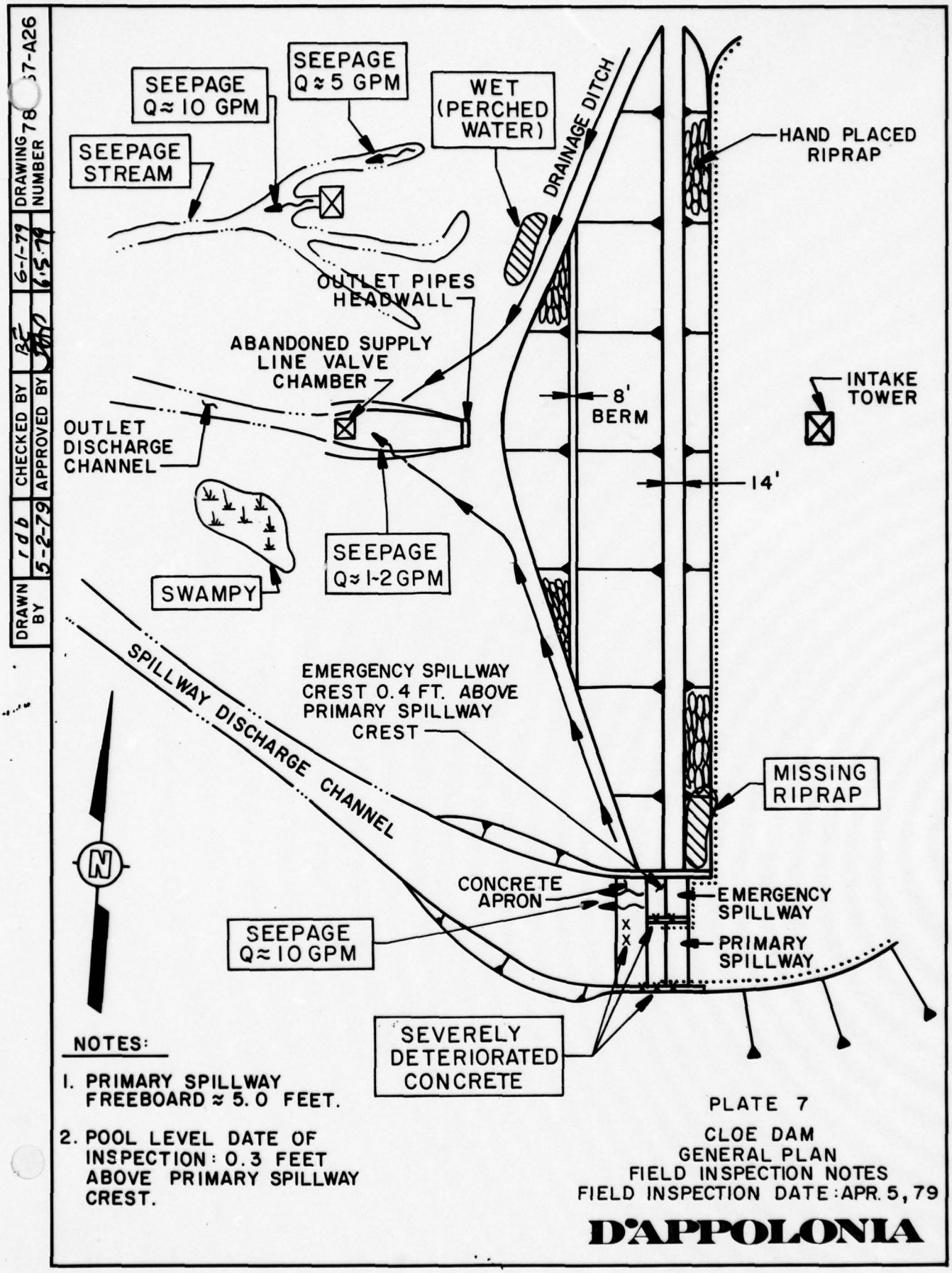
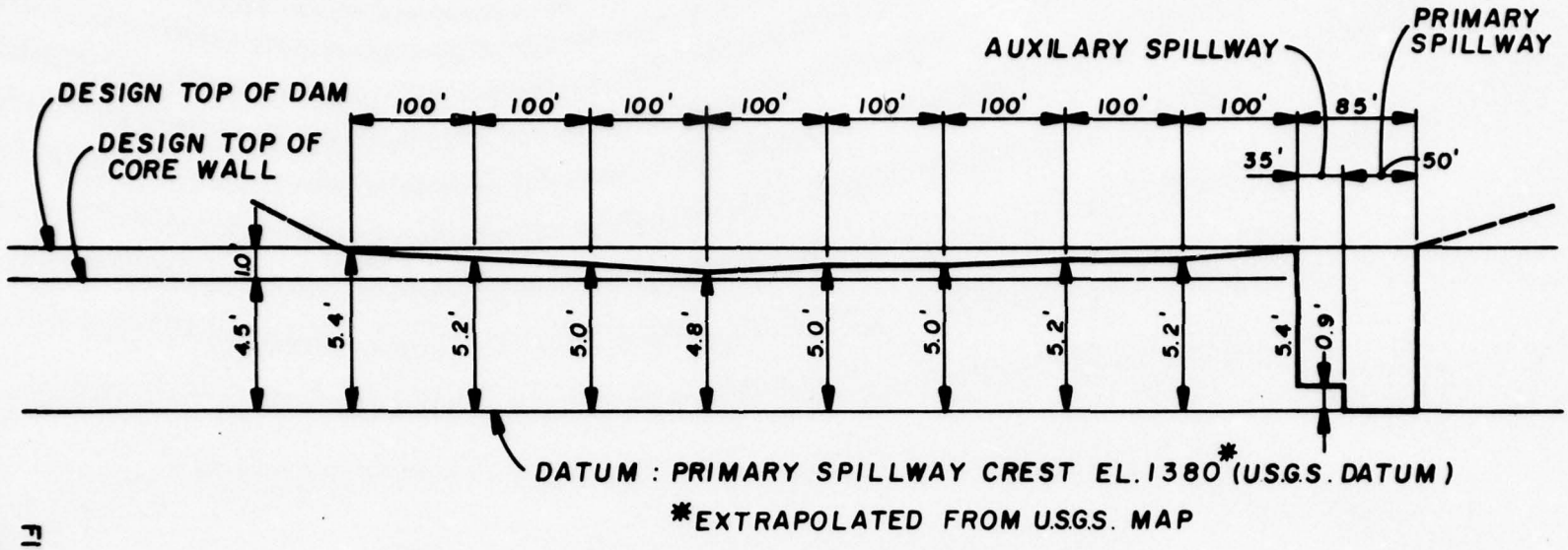


PLATE 6

D'APPOLONIA


DRAWING NUMBER 78 37-A26
DRAWN BY rdb 5-2-79
CHECKED BY BC 6-1-79
APPROVED BY JMD 6.5.79
SEEPAGE Q≈10 GPM
SEEPAGE Q≈5 GPM
WET (PERCHED WATER)
DRAINAGE DITCH
HAND PLACED RIPRAP
SEEPAGE STREAM
OUTLET PIPES HEADWALL
ABANDONED SUPPLY LINE VALVE CHAMBER
8' BERM
INTAKE TOWER
OUTLET DISCHARGE CHANNEL
14'
SEEPAGE Q≈1-2 GPM
SWAMPY
EMERGENCY SPILLWAY CREST 0.4 FT. ABOVE PRIMARY SPILLWAY CREST
SPILLWAY DISCHARGE CHANNEL
MISSING RIPRAP
N
CONCRETE APRON
EMERGENCY SPILLWAY
PRIMARY SPILLWAY
SEEPAGE Q≈10 GPM
SEVERELY DETERIORATED CONCRETE
NOTES:
1. PRIMARY SPILLWAY FREEBOARD ≈ 5.0 FEET.
2. POOL LEVEL DATE OF INSPECTION: 0.3 FEET ABOVE PRIMARY SPILLWAY CREST.
PLATE 7
CLOE DAM
GENERAL PLAN
FIELD INSPECTION NOTES
FIELD INSPECTION DATE: APR. 5, 79
D'APPOLONIA

DRAWN BY	ACS	CHECKED BY	BE	6/28/79	DRAWING NUMBER	367-A41
	6-28-79	APPROVED BY	[illegible]	7.3.79		



DAM CREST PROFILE
(LOOKING DOWNSTREAM)

PLATE 8

CLOE DAM
DAM CREST SURVEY
FIELD INSPECTION DATE: APR. 5, 79

D'APPOLONIA

NOTE:
DAM CREST IS SURVEYED RELATIVE TO PRIMARY SPILLWAY CREST LEVEL.

APPENDIX A

CHECKLIST
VISUAL INSPECTION
PHASE I

APPENDIX A

CHECKLIST
VISUAL INSPECTION
PHASE I

NDI I.D. PA-421

NAME OF DAM Cloe Dam COUNTY Jefferson STATE Pennsylvania ID# DER I.D. 33-2

TYPE OF DAM Earth HAZARD CATEGORY High

DATE(S) INSPECTION April 5, 1979 WEATHER Cloudy TEMPERATURE 40s

POOL ELEVATION AT TIME OF INSPECTION 1380.4(1) M.S.L. TAILWATER AT TIME OF INSPECTION 1363± M.S.L.

INSPECTION PERSONNEL:

Bilgin Erel

Wah-Tak Chan

REVIEW INSPECTION PERSONNEL:
(May 4, 1979)

E. D'Appolonia

L. D. Andersen

J. H. Poellot

Bilgin Erel

Bilgin Erel RECORDER

(1) Relative to assumed normal pool elevation 1380. See Section 1.2h of the report.

VISUAL INSPECTION
PHASE I
EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	None.	
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Crest of the dam is 4.8 to 5.2 feet above the primary spillway crest level (design crest level, 5.5 feet above primary spillway crest level).	
RIPRAP FAILURES	Riprap is in good condition. At two locations near the right and left abutments, portions of the riprap are missing. It appears to have been removed by vandals.	Missing riprap should be replaced.

VISUAL INSPECTION
PHASE I
EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	No signs of distress.	
ANY NOTICEABLE SEEPAGE	One swampy and one seepage area below the toe of the dam. See Plate 7 for location and seepage flow estimates.	
STAFF GAGE AND RECORDER	None.	
DRAINS	None.	

VISUAL INSPECTION
PHASE I
OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	The outlet conduit was not accessible for inspection. Only the downstream end was visible. No distress was observed.	
INTAKE STRUCTURE	Submerged.	
OUTLET STRUCTURE	No outlet structure. Outlet conduit would directly discharge into the outlet channel.	
OUTLET CHANNEL	No obstructions in the outlet channel that would significantly affect discharge capacity of the outlet works.	
EMERGENCY GATE	Fish Commission personnel reported that the outlet conduit sluice gates have not been operated in the recent past. Operation of the gates was not observed.	Operational condition of the outlet conduit sluice gate should be evaluated and necessary maintenance performed.

VISUAL INSPECTION
PHASE I
UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	The concrete in the spillway overflow structures has seriously deteriorated and cracked. There is seepage beneath the auxiliary spillway overflow structure.	Necessary repairs should be performed.
APPROACH CHANNEL	Submerged. Appears to be free of debris.	
DISCHARGE CHANNEL	Concrete is in poor condition.	Necessary repairs should be performed.
BRIDGE AND PIERS	None.	

VISUAL INSPECTION
PHASE I
GATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	N/A.	
APPROACH CHANNEL	N/A.	
DISCHARGE CHANNEL	N/A.	
BRIDGE PIERS	N/A.	
GATES AND OPERATION EQUIPMENT	N/A.	

VISUAL INSPECTION
PHASE I
INSTRUMENTATION

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None.	
OBSERVATION WELLS	None.	
WEIRS	None.	
PIEZOMETERS	None.	
OTHER	None.	

VISUAL INSPECTION
PHASE I
RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Gentle to moderately steep. No significant shoreline erosion was observed.	
SEDIMENTATION	Unknown.	
UPSTREAM RESERVOIRS	No significant impoundments.	

VISUAL INSPECTION
PHASE I
DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	No apparent obstructions immediately downstream from the dam that would affect the discharge capacity of the spillway.	
SLOPES	No apparent instability (immediately downstream from the dam).	
APPROXIMATE NUMBER OF HOMES AND POPULATION	Two homes approximately 1/2 mile downstream. Population: approximately 8.	

APPENDIX B

CHECKLIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
AND HYDROLOGIC AND HYDRAULIC
PHASE I

APPENDIX B

CHECKLIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

NAME OF DAM Cloe Dam
ID# NDI I.D. PA-421
DER I.D. 33-2

ITEM	REMARKS
AS-BUILT DRAWINGS	The design drawings are available in state files.
REGIONAL VICINITY MAP	See Plate 1.
CONSTRUCTION HISTORY	The dam was designed and constructed by BR&P Railroad Company with completion in 1910.
TYPICAL SECTIONS OF DAM	See Plate 3.
OUTLETS - PLAN - DETAILS - CONSTRAINTS - DISCHARGE RATINGS	See Plate 3.

CHECKLIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

ITEM	REMARKS
RAINFALL/RESERVOIR RECORDS	Not available.
DESIGN REPORTS	Not available.
GEOLOGY REPORTS	Not available.
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	Not available.
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	Not available.

CHECKLIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

ITEM	REMARKS
POST CONSTRUCTION SURVEYS OF DAM	None reported.
BORROW SOURCES	Unknown.
MONITORING SYSTEMS	None.
MODIFICATIONS	The dam was enlarged in 1923 by increasing the height of the embankment by six feet.
HIGH POOL RECORDS	Not recorded.

CHECKLIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

ITEM	REMARKS
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None reported.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None reported.
MAINTENANCE OPERATION RECORDS	Not available.
SPILLWAY PLAN SECTIONS DETAILS	See Plates 4 and 5.
OPERATING EQUIPMENT PLANS AND DETAILS	See Plates 3 and 6.

CHECKLIST
ENGINEERING DATA
HYDROLOGIC AND HYDRAULIC

DRAINAGE AREA CHARACTERISTICS: Three square miles, wood and pasturelands

ELEVATION; TOP NORMAL POOL AND STORAGE CAPACITY: 1380 (350 acre-feet)

ELEVATION; TOP FLOOD CONTROL POOL AND STORAGE CAPACITY: 1384.8 (590 acre-feet)

ELEVATION; MAXIMUM DESIGN POOL: 1384.8

ELEVATION; TOP DAM: 1384.8 (measured low spot)

SPILLWAY: (Primary Spillway)

a. Elevation 1380.0

b. Type Concrete overflow section

c. Width 50 feet (perpendicular to flow)

d. Length N/A

e. Location Spillover Middle of embankment

f. Number and Type of Gates None

OUTLET WORKS:

a. Type Two 24-inch cast-iron pipes

b. Location Center of embankment

c. Entrance Inverts 1345

d. Exit Inverts 1343

e. Emergency Draindown Facilities Outlet conduits

HYDROMETEOROLOGICAL GAGES:

a. Type None

b. Location None

c. Records None

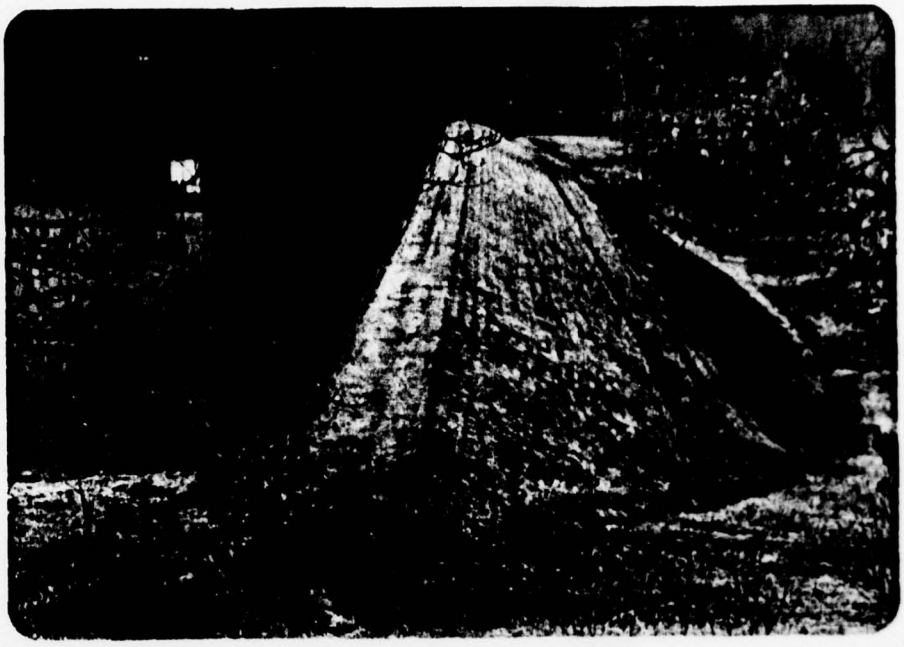
MAXIMUM NONDAMAGING DISCHARGE: 2550± cfs (full capacity of spillways)

APPENDIX C

PHOTOGRAPHS

LIST OF PHOTOGRAPHS
CLOE DAM
NDI I.D. NO. PA-421
APRIL 5, 1979

PHOTOGRAPH NO.	DESCRIPTION
1	Crest (looking south).
2	Primary spillway (right) and emergency spillway (left).
3	Spillways. Note deteriorating concrete.
4	Intake tower.
5	Outlet pipes.
6	Outlet pipe controls at intake tower.
7	Missing riprap near spillways.
8	Jackson Run at 1/2 mile downstream. Stream along pine trees.

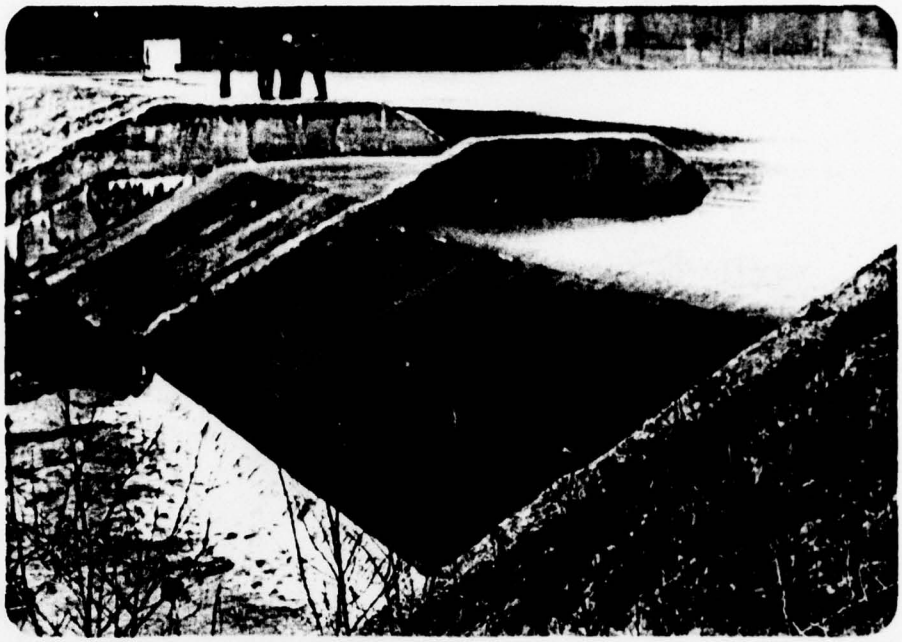


Photograph No. 1

Crest (looking south).

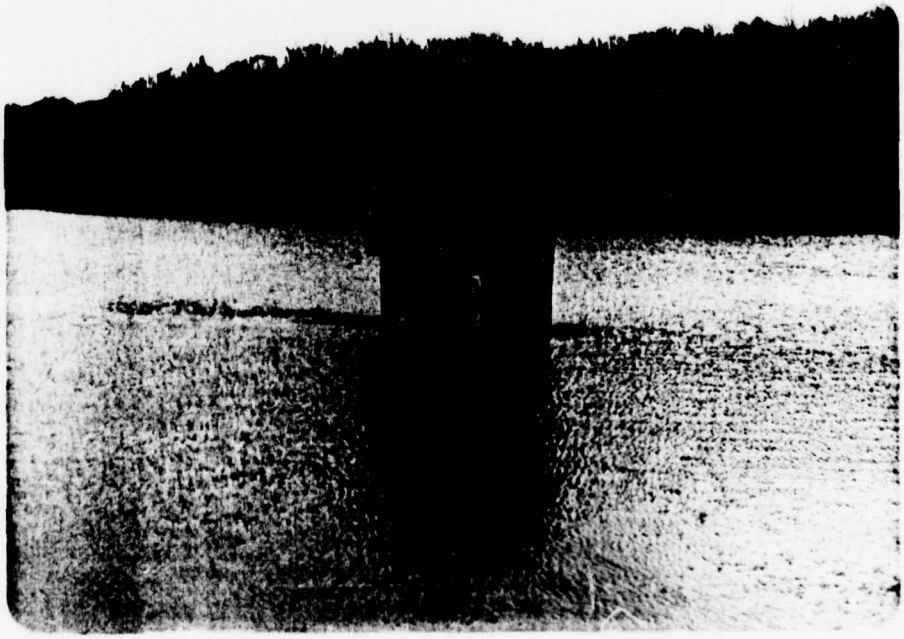
Photograph No. 2

Primary spillway (right) and emergency spillway (left).



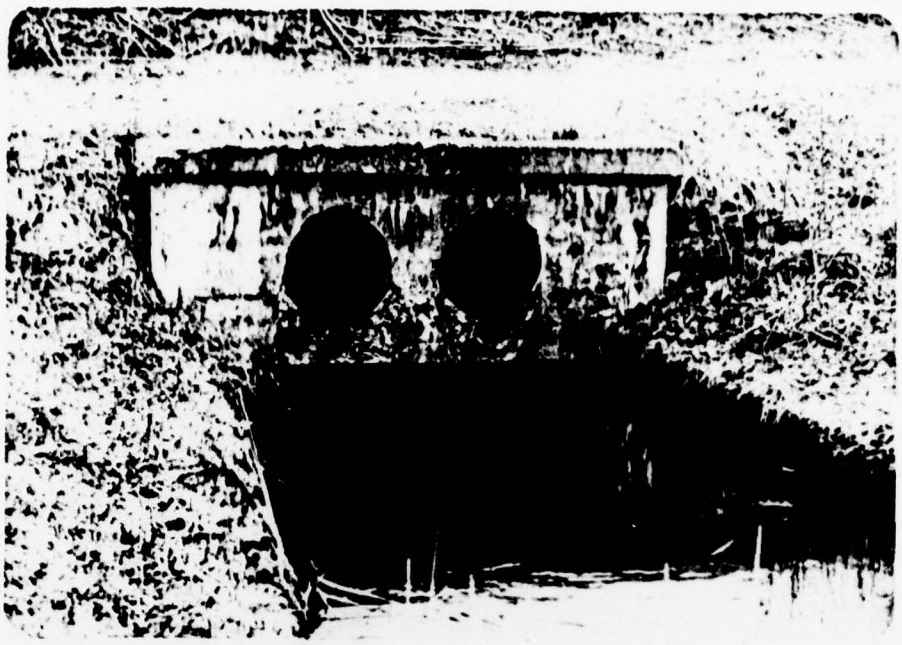
Photograph No. 3

Spillways. Note deteriorating concrete.



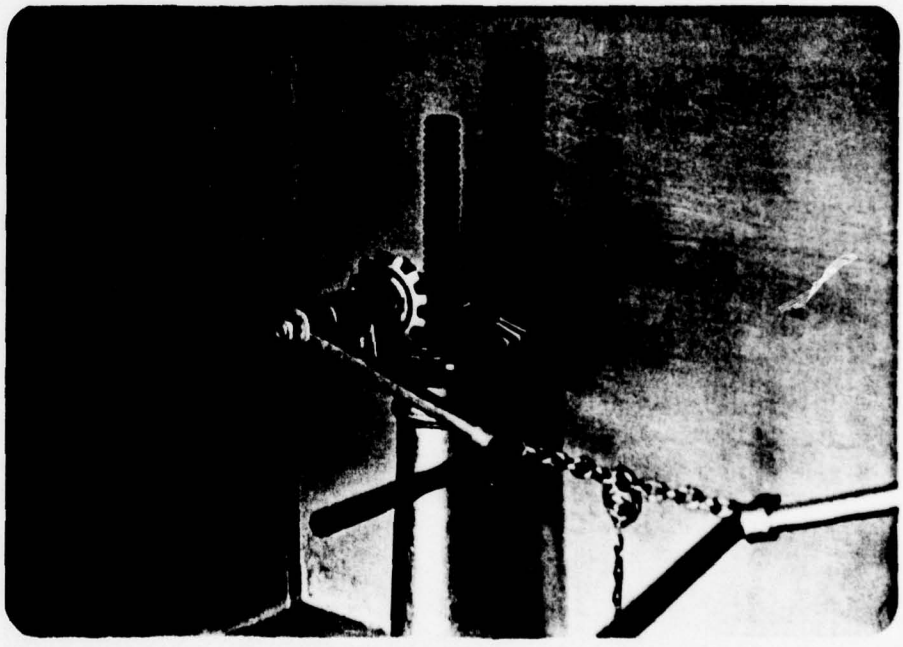
Photograph No. 4

Intake tower.



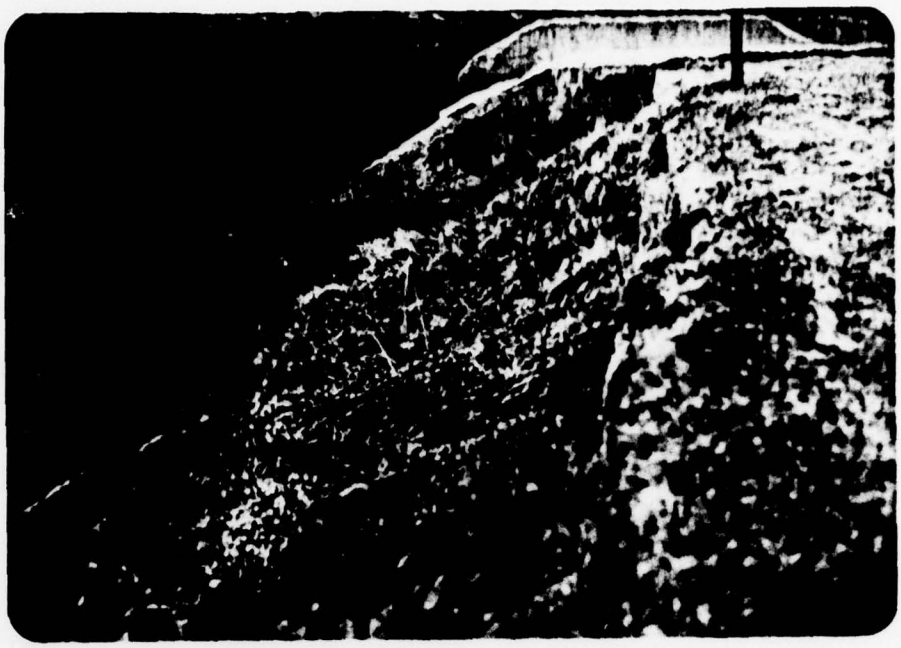
Photograph No. 5

Outlet pipes.



Photograph No. 6

Outlet pipe controls at intake tower.



Photograph No. 7

Missing riprap near spillways.

Photograph No. 8

Jackson Run at 1/2 mile downstream. Stream along pine trees.

APPENDIX D
CALCULATIONS

HYDROLOGY AND HYDRAULIC ANALYSIS
DATA BASE

NAME OF DAM: Cloe Dam (NDI I.D. PA-421)

PROBABLE MAXIMUM PRECIPITATION (PMP) = 23.5 INCHES/24 HOURS[1]

STATION	1	2		3	4	5
Station Description	Cloe Lake	Cloe Dam				
Drainage Area (square miles)	3.0	0				
Cumulative Drainage Area (square miles)	3.0	3.0				
Adjustment of PMF for Drainage Area (%)[2]						
6 Hours	140	-				
12 Hours	130	-				
24 Hours	120	-				
48 Hours	102	-				
72 Hours	-	-				
Snyder Hydrograph Parameters						
Zone[3]	24	-				
C_p/C_t[4]	0.45/1.6	-				
L (miles)[5]	2.8	-				
L_{ca} (miles)[5]	1.0	-				
$t_p = C_t(L \cdot L_{ca})^{0.3}$ (hours)	2.2	-				
Spillway Data		Primary	Emergency			
Crest Length (ft)	-	50	35			
Freeboard (ft)	-	4.8	4.2			
Discharge Coefficient	-	3.1	3.1			
Exponent	-	1.5	1.5			

(1) Hydrometeorological Report 33 (Figure 1), U.S. Army, Corps of Engineers, 1956.

(2) Hydrometeorological Report 33 (Figure 2), U.S. Army, Corps of Engineers, 1956.

(3) Hydrological zone defined by Corps of Engineers, Baltimore District, for determining Snyder's Coefficients (C_p and C_t).

(4) Snyder's Coefficients.

(5) L = Length of longest water course from outlet to basin divide.
L_{ca} = Length of water course from outlet to point opposite the centroid of drainage area.

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
**********
    1                A1   SNYDER UNIT HYDROGRAPH, FLOOD ROUTING AND DAM OVERTOPPING ANALYSIS
    2                A2   CLOE DAM, JEFFERSON COUNTY, NDI-I.D.PA.421            PROJECT NO. 78-367-19
    3                A3   20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, AND 100% PMF
    4                B    300       0      10       0       0       0       0       0      -4       0
    5                B1     5
    6                J      1       9       1
    7                J1    .2      .3      .4      .5      .6      .7      .8      .9      1.
    8                K      0       1                                       1
    9                K1   CALCULATION OF INFLOW HYDROGRAPH TO CLOE DAM
   10                M      1       1     3.0               3.0                               1
   11                P              23.5     102     120     130     140
   12                T                                                      1.0     .05             .0151
   13                W  2.195     .45
   14                X   -1.0    -.05     2.0
   15                K      1       2                                       1
   16                K1   ROUTING FLOW THROUGH CLOE DAM
   17                Y                                       1       1
   18                Y1     1                                                349.9     -1
   19                Y4 1380.  1380.3  1380.6  1381.0  1381.5  1382.0  1383.0  1384.0  1386.0  1388.0
   20                Y5    0.    25.4    71.7   181.7   375.8   615.5  1203.7  1912.2  3624.3  5667.5
   21                $S 349.9  1296.1
   22                $E 1380.   1400.
   23                $$ 1380.
   24                $D1384.8     3.1     1.5   780.0
   25                $L  100.    300.    400.    675.    780.
   26                $V1384.8 1384.95  1385.0  1385.2  1385.4
   27                K     99
```

COMPUTER INPUT OVERTOPPING ANALYSIS

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1 .20	RATIO 2 .30	RATIO 3 .40	RATIO 4 .50	RATIO 5 .60	RATIO 6 .70	RATIO 7 .80	RATIO 8 .90	RATIO 9 1.00
HYDROGRAPH AT	1	3.00	1	1125.	1687.	2249.	2811.	3374.	3936.	4498.	5060.	5623.
	(	7.77)	(	31.84)(	47.77)(	63.69)(	79.61)(	95.53)(	111.45)(	127.37)(	143.30)(	159.22)
ROUTED TO	2	3.00	1	1024.	1566.	2114.	2667.	3312.	3906.	4477.	5042.	5605.
	(	7.77)	(	29.01)(	44.34)(	59.85)(	75.52)(	93.77)(	110.62)(	126.78)(	142.78)(	158.72)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1380.00	1380.00	1384.80
STORAGE	350.	350.	577.
OUTFLOW	0.	0.	2597.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.20	1382.70	0.00	477.	1024.	0.00	43.00	0.00
.30	1383.51	0.00	516.	1566.	0.00	42.83	0.00
.40	1384.24	0.00	550.	2114.	0.00	42.83	0.00
.50	1384.87	.07	580.	2667.	1.00	42.67	0.00
.60	1385.25	.45	598.	3312.	2.83	42.33	0.00
.70	1385.46	.66	608.	3906.	4.00	42.17	0.00
.80	1385.62	.82	616.	4477.	4.83	42.00	0.00
.90	1385.77	.97	623.	5042.	5.50	42.00	0.00
1.00	1385.91	1.11	629.	5605.	6.17	42.00	0.00

OVERTOPPING ANALYSIS SUMMARY

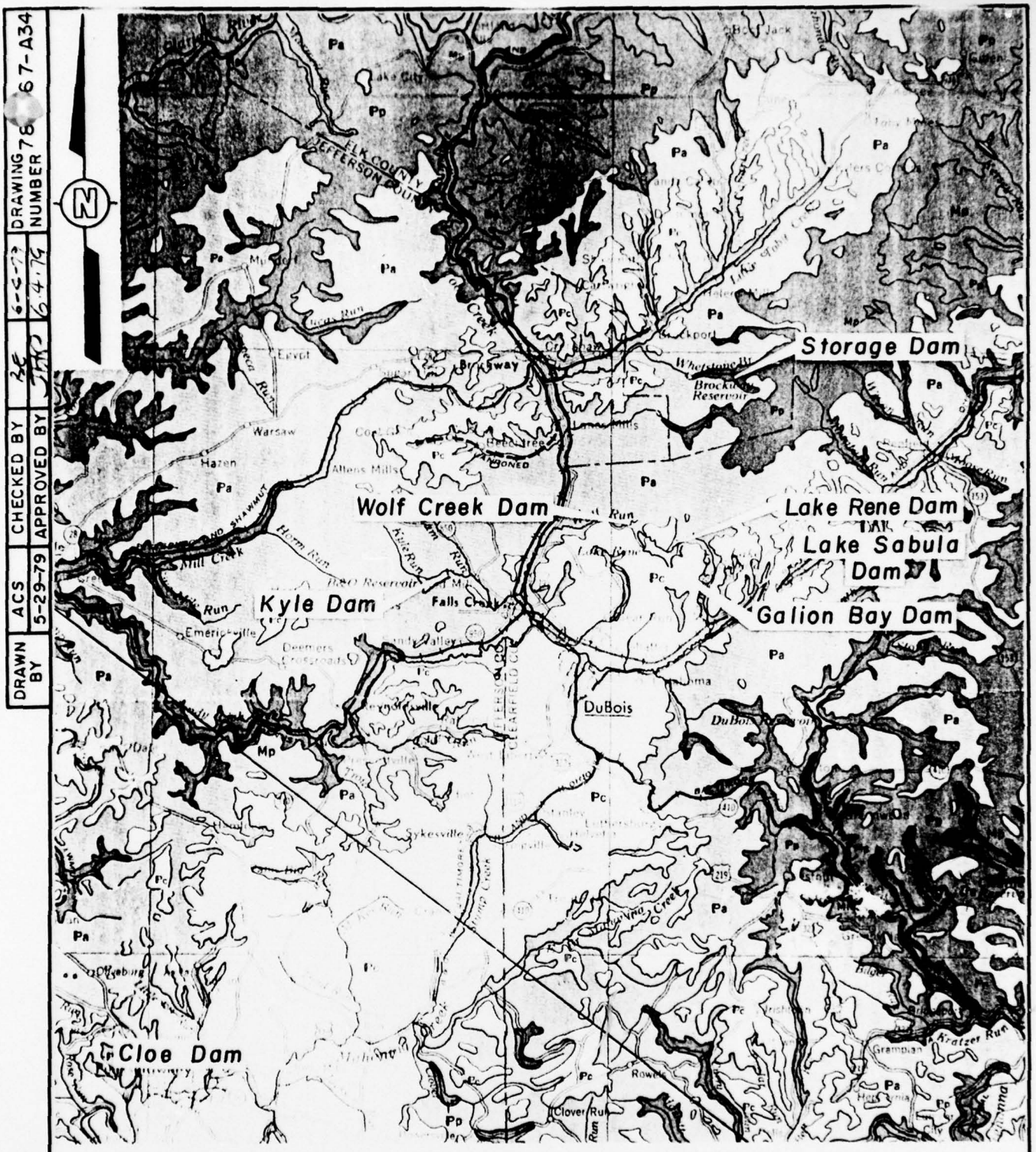
APPENDIX E

REGIONAL GEOLOGY

APPENDIX E
REGIONAL GEOLOGY

Cloe Dam is located on strata of the Conemaugh Formation (Pennsylvanian Age). The Conemaugh Formation is characterized by interbedded sandstones, shales, claystones, thin marine limestones, and thin coal seams. The claystones are also known as redbeds and are prone to landslides.

The Lower Freeport coal has been mined to within one mile northwest of the dam. Mining was abandoned due to reported fault conditions. Mining one mile north of the dam was abandoned due to bad roof conditions and faults. Mining has been done near the northeast part of the dam through the Lower Freeport coal which is 28 inches thick at the site. The Kittanning coals are only 10 inches thick at the site and not minable. The Upper and Lower Freeport coals may be locally faulted out or absent.



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	5-29-79	APPROVED BY	6.4.79	

SCALE

0 2 4 6 8 10 miles

STORAGE, WOLF CREEK, KYLE, LAKE RENE, LAKE SABULA, GALION BAY AND CLOE DAM

GEOLOGY MAP

REFERENCE:

GEOLOGIC MAP OF PENNSYLVANIA PREPARED BY COMMONWEALTH OF PENNA. DEPT. OF INTERNAL AFFAIRS, DATED 1960, SCALE 1" = 4 MILES

D'APPOLONIA

DRAWN BY	ACS	CHECKED BY		DRAWING NUMBER 78 J7-A35
	6-1-79	APPROVED BY	6.4.79	

PENNSYLVANIAN

APPALACHIAN PLATEAU

Pm — **Monongahela Formation**
Cyclic sequences of sandstone, shale, limestone and coal; limestone prominent in northern outcrop areas; shale and sandstone increase southward; commercial coals present; base at the bottom of the Pittsburgh Coal.

Pc — **Conemaugh Formation**
Cyclic sequences of red and gray shales and siltstones with thin limestones and coals; massive Mahoning Sandstone commonly present at base; Ames Limestone present in middle of sections; Brush Creek Limestone in lower part of section.

Pa — **Allegheny Group**
Cyclic sequences of sandstone, shale, limestone and coal; numerous commercial coals; limestones thicken westward; Vanport Limestone in lower part of section; includes Freeport, Kittanning, and Clarion Formations.

Pp — **Pottsville Group**
Predominantly sandstones and conglomerates with thin shales and coals; some coals mineable locally.

ANTHRACITE REGION

Ppp — **Post-Pottsville Formations**
Brown or gray sandstones and shales with some conglomerate and numerous mineable coals.

Pp — **Pottsville Group**
Light gray to white, coarse grained sandstones and conglomerates with some mineable coal; includes Sharp Mountain, Schuylkill, and Tumbling Run Formations.

MISSISSIPPIAN

Mmc — **Mauch Chunk Formation**
Red shales with brown to greenish gray flaggy sandstones; includes Greenbrier Limestone in Fayette, Westmoreland, and Somerset counties; Loyalhanna Limestone at the base in southwestern Pennsylvania.

Mp — **Pocono Group**
Predominantly gray, hard, massive, cross-bedded conglomerate and sandstone with some shale; includes in the Appalachian Plateau Burgoon, Shenango, Cuyahoga, Cussewago, Corry, and Knapp Formations; includes part of "Oswayo" of M. L. Fuller in Potter and Tioga counties.

GEOLOGY MAP LEGEND

REFERENCE:
GEOLOGIC MAP OF PENNSYLVANIA PREPARED BY COMMONWEALTH OF PENNA. DEPT. OF INTERNAL AFFAIRS, DATED 1960, SCALE 1" = 4 MILES

D'APPOLONIA